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RACINE AND CEDARVILLE CYSTIDS AND BLASTOIDS WITH NOTES ON OTHER ECHINODERMS.

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No adequate study of the cystids of the Cedarville dolomite of Ohio ever has been undertaken. In Volume III of the Report of the Geological Survey of Ohio, published in 1876, *Caryocrinites ornatus*, *Gomphocystites glans*, *Hallicystis imago*, and *Holocystites abnormis* are listed from Bierley's quarry, along the creek four and a half miles east of Greenville, in Darke County, Ohio. On page 417 of the same volume *Holocystites cylindricus* is included in the list of fossils from the Niagara group, but no locality is mentioned. However, of the species cited, *Caryocrinites ornatus* is restricted to the Rochester shale of New York and the adjacent parts of Canada, and, although several species of *Caryocrinites* occur in the Cedarville dolomite of Ohio, none of these belong to the Rochester form, all being undescribed so far. *Gomphocystites glans*, moreover, is a Racine species with an elongated stipe, whereas all of the specimens of *Gomphocystites* found so far in the Cedarville dolomite of Ohio have short stipes. *Hallicystis imago* is represented by typical specimens from Springfield, Ohio. Forms resembling *Holocystites abnormis* and *H. cylindricus* also are present in the Cedarville dolomite of Ohio, but have not yet been studied with sufficient care to insure their identity. On the other hand, *Holocystites alternatus* is represented by characteristic specimens from several localities in Ohio, and a primitive species of *Holocystites* was described recently (OHIO JOUR. SCIENCE, 17, p. 203, pl. 9, figs. 3 A, B, C; pl. 10, fig. 8) under the name *Holocystites greenvillensis* Foerste. In the same paper two cystids were described under the terms *Callocystites jewetti elongata* Foerste and *Callocystites sphaeroidalis* Foerste. Recent investigations have shown, however, that the latter species is founded on the exterior of *Cælocystis subglobosus*, a species already described from the Racine dolomite, the latter being founded on casts of the interior of the theca.

Most cystids from the Cedarville dolomite of Ohio evidently are related closely to those of the Racine dolomite of Wisconsin and Illinois, described by Hall in 1868 in the 20th Report of the New York State Cabinet of Natural History. Several of these Racine species were restudied by Schuchert in his paper on *Siluric and Devonian Cystidea and Camarocrinus*, published in the 47th volume of the Smithsonian Miscellaneous Collections in 1904, but some of the other Racine species demand equally detailed consideration and the results of recent studies on several of these species are incorporated here.

As a result of these studies we now know the appearance of the exterior of the theca of *Cælocystis subglobosus* (Hall). It has been learned that *Aethocystites* and *Lysocystites* are identical genera, the former being founded on the exterior of one species, and the latter on the interior of a second species, but both species are congeneric. *Crinocystites chrysalis*, moreover, has been identified as the anal tube of some species of *Eucalyptocrinus*.

It is now recognized that the figures accompanying the original descriptions of *Lysocystites nodosus* and *Crinocystites chrysalis* were drawn in inverted positions. After some difficulty it has been found possible to diagram the plate system of the type of *Cælocystis subglobosus*, confirming the identifications made by Schuchert, and considerable variation has been observed in the general form of different specimens and in the outlines, arrangement, and number of the plates. In *Holocystites alternatus*, the intercalation of supplementary plates has been made the subject of further study.

Only one species of blastoids is known from the Cedarville dolomite of Ohio, *Troostocrinus subcylindricus* (Hall and Whitfield), published in 1875, in volume 2 of the Paleontology of Ohio. The occurrence of *Troostocrinus* is noted also in the Racine of the Chicago area, the Bainbridge of eastern Missouri, and the top of the Laurel limestone of southeastern Indiana.

The Ohio species, *Eucalyptocrinus proboscidiæ* Miller, is refigured to show its close relationship to *Crinocystites chrysalis* Hall.

The problematical organisms described as *Cyclocystoides*, and usually regarded as *Edrioasteroids*, show variations in structure suggesting the presence of several groups of generic rank, and for two of these groups the terms *Narrawayella* and *Savagella* are proposed here.

A new genus of cystids, evidently closely related to *Amygdalocystites*, from the Kimmswick limestone of southeastern Missouri, is named *Wellerocystis*.

LIST OF SPECIES.

CYSTOIDEA.

Malocystidæ.

1. *Wellerocystis kimmswickensis* Gen. et sp. nov.
Comarocystites and Echinosphærites in Kimmswick strata.

Callocystidæ.

2. *Hallicystites imago* (Hall).
3. *Callocystites jewetti elongatus* Foerste.
4. *Cælocystis subglobosus* (Hall).

Cryptocrinidæ.

5. *Lysocystites sculptus* (Miller).
6. *Lysocystites nodosus* (Hall).

Sphæronitidæ.

7. *Holocystites alternatus* Hall.
8. *Holocystites greenvillensis* Foerste.
9. *Allocystites hammelli* Miller.

Gomphocystidæ.

10. *Gomphocystites indianensis* Miller.
11. *Gomphocystites* sp. (From the Louisville limestone.)
12. *Gomphocystites bownockeri* Sp. nov.

EDRIOASTEROIDEA.

Cyclocystoididæ.

- Narrawayella* Gen. nov.
- Narrawayella raymondi* Sp. nov.
- Savagella* Gen. nov.
13. *Savagella ornatus* Savage.
14. *Cyclocystoides* (?) *illinoisensis* Miller and Gurley.

BLASTOIDEA.

Troostoblastidæ.

15. *Troostocrinus sanctipaulensis* Sp. nov.
16. *Troostocrinus reinwardti minimus* Var. nov.
17. *Troostocrinus subcylindricus* (Hall and Whitfield).
18. *Troostocrinus* sp. (From the Racine dolomite.)

CRINOIDEA.

Calyptocrinidæ.

19. *Crinocystites chrysalis* Hall.
Eucalyptocrinus proboscidiæ Miller.
Eucalyptocrinus slocomi Sp. nov.
20. *Periechocrinus cylindricus*. Foerste.

Wellerocystis Gen. nov.

Amygdalocystites and *Canadocystis*.—The genera *Amygdalocystites* and *Canadocystis* agree in having two divergent main food-grooves which curve toward their distal ends in a more or less distinctly dextral direction. These food-grooves are supported on single series of plates, which rise more or less abruptly along the convexly curved outer side of the rays and which support on this side a single series of brachioles, while the main food-grooves occupy the concavely curved side of the rays. In both genera, the anal opening lies exterior to the convexly curved side of the nearest one of the two rays, but near a vertical plane passing through the oral aperture and parallel to the proximal straighter part of the rays.

Wellerocystis.—In a cystid found by Prof. Stuart Weller in the Kimmswick limestone of eastern Missouri a closely similar structure is found. Its general aspect is nearest that of *Amygdalocystites*, but there are 3 instead of 2 rays, that one of the primary rays which is most distant from the anal opening branching within a short distance from the oral aperture, the new branch being added on the left side of the primary ray. Moreover, the anal opening, as exposed in the type specimen, lies within the area enclosed by the concavely curved side of the undivided ray. From *Amygdalocystites* this cystid differs in its ovoid form, and in the absence of radiate ribbing on the thecal plates, the latter being gently convex and minutely granular. From *Canadocystis* it differs in the different location of its anal opening, in the branching of one of its rays, and in the more decurrent growth of the tips of these rays. However, if the Kimmswick specimen be so oriented that its anal opening is on the same side as in *Canadocystis*, then the attachment area for the column in both cases will be found on the diagonally opposite side of the basal part of the theca.

Genotype.—*Wellerocystis kimmswickensis* Sp. nov. Genus named in honor of Prof. Stuart Weller, in recognition of his many important contributions to American Paleontology. Genotype formed by the Kimmswick cystid mentioned above.

In the United States National Museum at Washington there is another undescribed Kimmswick cystid, collected by Dr. E. O. Ulrich, apparently congeneric with *Wellerocystis kimmswickensis*, but with each of the two primary rays having two additional branches, thus forming a total of six.

Wellerocystis kimmswickensis Sp. nov.

(Plate I, Figs. 12 A, B.)

Theca 20 mm. in height and 15 mm. in width, ovoid in form, with attachment area for column about 4 mm. from the vertical axis, on the side opposite to that occupied by the anal opening. Oral aperture at the summit of the theca, a millimeter long in a direction parallel to the proximal part of the main food-grooves, and about a quarter of a millimeter in width, the elongation being in a direction almost at right angles to a vertical plane passing through both the anal opening and the attachment area for the column. That one of the two primary rays

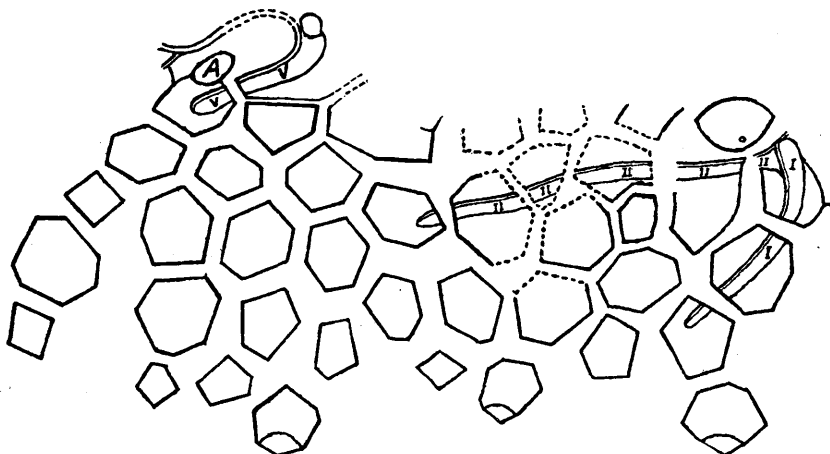


FIG. 1. Diagram showing the arrangement of the plates in *Wellerocystis kimmswickensis*.

The outlines of the plates in the apical region, between the rays, are very uncertain, but are indicated as well as they can be ascertained by means of dotted lines. The position of the anal aperture is at A. The three recumbent rays are numbered I, II and V. The food-grooves follow those sides of the rays which are marked by two closely placed parallel lines. The oral aperture is represented in the diagram by a circle at the upper end of ray V. The food-groove extending from the oral aperture toward the left connects with rays I and II. There are 3 basal plates, indicated by parts of a circle at their bases, the latter limiting the areas of articulation of these basal plates with the column.

which encircles the anal aperture remains unbranched and is only 10 mm. in length, measuring along its convexly curved side. The other primary ray, on the opposite side of the oral aperture, is 18 mm. in length; about 2.5 mm. from this aperture a branch of intermediate length is added on the left side of this second ray, thus forming a total of three rays. The number of brachioles supported by the ray encircling the anal aperture was about 5; the number on the other primary ray equalled about 7 or 8, and that on the branch of this second ray was about 10. Viewed directly from above, the food-grooves with their branches leading to the facets formerly supporting the brachioles resemble those

of *Canadocystis emmonsii*, but the general appearance of upper surface of the plates supporting the food-grooves is more convex. The madreporite and gonopore can not be identified with certainty.

Number of thecal plates, as far as can be determined from the single specimen at hand, about 40, arranged more or less irregularly, but with a tendency toward oblique rows parallel to the distal ends of the rays, apparently about 5 or 6 plates in a row, unless the number of apical plates is greater than can be determined from this single specimen.

Surface relatively smooth, without radiate folds as in *Amygdalocystites*; probably with minute granules.

LOCALITY AND HORIZON.—From the Kimmswick limestone at Glen Park, in Jefferson County, Missouri. Type numbered 10727 in Walker Museum at Chicago University.

REMARKS.—*Wellerocystis* presents combinations of characteristics found in *Amygdalocystites* and *Canadocystis*. However, since *Canadocystis* appears to be a less specialized type, it is probable that the relationship of *Wellerocystis* is closer to the latter genus. Little can be said about its relationship to *Malocystites* until the type of the genus, *Malocystites murchisoni* Billings becomes better known. Billings stated that the two primary rays of this species branched so as to produce two sets of branches, 4 in each set, and he figured the supporting plates of these branches as uniserial, but so unlike those of *Amygdalocystites* and *Canadocystis* in appearance that close relationship remains in doubt.

COMAROCYSTITES AND ECHINOSPHERITES IN KIMMSWICK STRATA.

In the United States National Museum at Washington there are specimens of *Comarocystites shumardi* Meek and Worthen and of a species of *Echinospaerites* resembling *E. aurantium* (Gyllenhal), which were obtained by Dr. E. O. Ulrich in the railroad cut half a mile south of the station at Thebes, Illinois, in the upper part of the Kimmswick formation, above the more richly fossiliferous part of the Kimmswick section whose fauna was investigated by Savage in detail. This occurrence indicates that the cystids named belong at the top of the Kimmswick formation and not at its base (Denison Univ. Bull. 19, 1920, pp. 179, 180, 181, 184, 196). At Thebes they are associated with a species closely resembling *Wellerocystis kimmswickensis*. There are two primary rays; that primary ray which is most distant from the anal opening branches on its left side, thus making a

total of three rays. The supporting plates for the rays are uniserial, and all brachioles are located on the left side of the rays, when the latter are held so that their proximal parts are nearest the observer. The chief difference of this new species of cystid of the Thebes locality from *Wellerocystis* appears to be in the character of its plates, the latter being coarsely radiate with bold cuneate ridges, much coarser than in *Amygdalocystites florealis*. The anal opening is located on the convexly curved side of the unbranched primary ray.

Dr. E. O. Ulrich has collected *Comarocystites shumardi* and *Echinospaerites* cf. *aurantium* from the upper Kimmswick also at Cape Girardeau, Missouri. *Wellerocystis kimmswickensis* probably belongs to the same horizon but was found farther north in Missouri, in Jefferson County. No trace of this upper Kimmswick fauna has been found so far in northeastern Missouri, in Ralls or Pike Counties.

2. *Hallicystis imago* (Hall).

(Plate I, Figs. 7, 8; Plate II, Figs. 7 A, B, C.)

Apiocystites imago Hall, 20th Rep. New York State Cab. Nat. Hist., 1868, p. 314, Pl. 12, Fig. 12, Pl. 12a, Fig. 9.

Hallicystis imago Jaekel, Stammesgeschichte d. Pelmatozoen, 1, Thecoidea u. Cystoidea, 1899, p. 288, Pl. 15, Fig. 3.

Hallicystis elongata Jaekel, Idem, p. 288.

Hallicystis imago Foerste, Ohio Jour. Sci., 17, 1917, p. 235, Fig. 1; Pl. II, Fig. 2.

Typical *Hallicystis imago* seems to be characterized by an attenuate base for the attachment of the column, the attachment area being small compared with that of *Callocystites jewetti-elongatus*. The pectinirhombs appear to be narrow with relatively few dichopores. These features are shown even by the smallest, and presumably youngest, specimens (Plate I, Fig. 8) at hand.

Hallicystis elongatus appears to be a broader form, less attenuate at the base, with the anus occupying a relatively lower position; the pectinirhombs are conspicuously larger, and the dichopores on plates 14-15 number about 14, which is distinctly more than in typical *Hallicystis imago*.

It has not yet been determined whether these forms are distinct species or merely variations of the same species. This will require a sufficient number of specimens to determine their range of variation.

LOCALITY AND HORIZON.—From the Racine dolomite at Racine, Wisconsin, and in the Chicago area, in Illinois. Also from the Cedarville dolomite at Cedarville, Ohio.

3. *Callocystites jewetti-elongatus* Foerste.

(Plate II, Fig. 6.)

Callocystites jewetti-elongata Foerste, Ohio Jour. Sci., 17, 1917, p. 236, Fig. 2, Pl. II, Figs. 6 A, B.

Base of cast of interior of the theca, showing a faint tendency toward a quadrate outline owing to faint ridges connecting middle points of the four basals. The area of attachment for the column is relatively large. Compare with basal view of *Halicystis imago* (Hall).

LOCALITY AND HORIZON.—From the Cedarville dolomite at Cedarville, Ohio.

4. *Cœlocystis subglobosus* (Hall).

(Plate I, Figs. 1 A, B. Plate II, Figs. 1 A, B; 2 A, B; 3 A, B, C; 4; 5 A, B, C, D; 6.)

Hemicosmites subglobosus Hall, 20th Rep. New York State Cab. Nat. Hist., 1870, p. 359, Pl. 12, Fig. 13.*Sphærocystites dolomiticus* Jaekel, Stammesgeschichte der Pelmatozoen, 1899, p. 289, plate diagram 63.*Cœlocystis subglobosus* Schuchert, Smithsonian Misc. Coll., 47, 1904, p. 248, plate diagrams 36, 37.*Callocystites spheroidalis* Foerste, Ohio Jour. Sci., 17, 1917, p. 238, Fig. 3; Pl. 12, Fig. 5.

Type figured by Hall.—The type figured by Hall is numbered 2027 in the American Museum of Natural History in New York City. It was obtained in the Racine dolomite at Racine, Wisconsin. This type never has been adequately figured or described, though the necessity for this has been removed largely by the excellent plate diagrams and descriptions published by Prof. Schuchert as the result of studies based on material from the same horizon but from the Chicago area.

The type figured by Hall (Plate II, Figs. 1 A, B) is a cast of the interior of an abnormal specimen, lacking Plate 11. Possibly plates 16 and 11 are represented by a single plate in which the two component plates no longer can be differentiated. In the latter case, plate 11 may be regarded as attached to plate 16 and also as diminished in size and lifted in position, thus changing the outlines of the surrounding plates 5, 6 and 17, and affecting even the more distant plates 12 and 18. The upper part of the theca has been depressed obliquely along plates 9, 10, 15, 16 and 22, causing the circumoral part of the theca to be pushed backward, and producing a corresponding distortion of all of the lateral plates. The anal aperture, being situated on the right of the sagittal place passing through the mouth, hydropore, and aboral pole, lies within one of the areas of maximum distortion, the upper part of the surrounding plates inclining strongly backward. Plates 23 and 13 have weathered away. The most important difference from normal specimens consists in the small width and slight depth of the invaginated part of the base of this cast of the interior.

In normal specimens (Plate II, Fig. 5 C), the base of the cast of the interior of the theca is broadly, deeply, and quadrangularly invaginated.

The angles of the quadrangular outline of the invaginated part are strongly rounded, and terminate along the median line of the four basal plates. Measured diagonally across the invaginated area, from one angle to that diagonally opposite, the longer diameters of this area vary usually from 14 to 16 mm.; the depth of the invagination usually is only 2 or 3 mm., but may equal 4 mm. occasionally.

Jaekel, in diagramming that specimen of *Cælocystis subglobosus* for which he proposed the name *Sphærocystites dolomiticus*, also found one plate missing, only one plate occurring in the area where usually the two plates 9 and 10 should occur. Plates 11 and 5 appeared to have enlarged, crowding the single plate representing both plates 9 and 10 toward the left. In consequence, the outlines of several plates have been altered considerably. Plate 4 has an angular top, and plate 15 has a corresponding angular base.

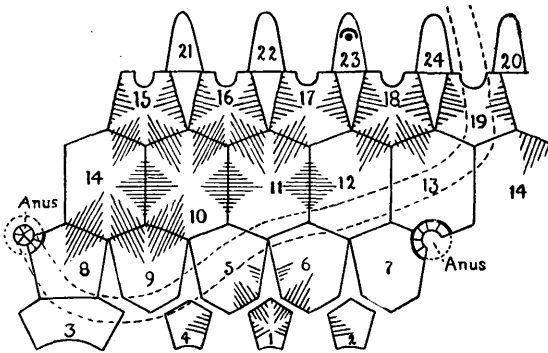


FIG. 2. The actual distribution of all pore-rhombs known with certainty in the *Glyptocystidae*, showing how a space is left clear where the gut may be supposed to have pressed against the thecal wall. Copied from Bather, in *Caradocian Cystidea* from Girvan, 1913, page 437.

If the gut, pressing against the interior of the thecal wall, followed a path across plates 13, near the sutures between plates 18 and 12, 17 and 6, 11 and 5, across plates 10 and 9, the lower part of 14 and the middle of 8, to the anal aperture, then in many abnormal specimens showing reductions in the size and number of plates or changes in outline, these changes are more frequent along the supposed path of the gut. (Bather, *Echinodermata*, 1900, p. 58, fig. 20).

An entirely different type of abnormality is represented by the second specimen of *Cælocystis subglobosus* (Plate II, Figs. 5 A, B, D; Schuchert, loc. cit., fig. 37) diagrammed by Schuchert. In this case the upper part of the theca is enlarged by the introduction of four accessory plates, numbered 15', 16', 18', and 21', by Schuchert. The first three of these accessory plates belong to the fourth primary circle of thecal plates which includes plates 15, 16, 17, 18 and 19. The accessory plate 21' belongs to the fifth or circum-oral circle. In each case the accessory plate is assumed to have been added on the left side of the corresponding primary plate, as though something had dragged the primary plates

under consideration toward their right, or in a counter-clockwise direction. These changes have been accompanied by an increase in the height of the theca and a steepening of its lateral walls. The column, at its contact with the base of the theca, has a diameter of 6.5 mm.

In a specimen numbered 1603 (Plate II, Fig. 4), belonging to the Illinois State Museum of Natural History, from the Racine dolomite at Racine, Wisconsin, the lateral diameter of the theca is distinctly narrower than the one from front to rear, the theca is rather high, and the circum-oral parts have been pushed strongly forward, therefore, in a direction opposite to that shown by the type of *Cælocystis subglobosus*.

Ohio specimens.—In Ohio, *Cælocystis subglobosus* is known from the Cedarville dolomite both from Cedarville, and from the Moodie quarry at Wilmington.

The Cedarville specimen (Plate II, Figs. 3 A, B, C) is low and broad, with only a faintly invaginated base, but otherwise does not differ from typical specimens from the Chicago area.

The Wilmington specimen (Plate II, Figs. 2 A, B) is a much taller specimen and also has a faintly invaginated base. Faint flexures on this cast of the interior of the theca suggest that ambulacra resembling those of *Callocystites* reached as low as the margin of the invaginated part of the base, branching at least once, at about the level of the anal aperture.

Apparently this species is remarkable, among *Glyptocystidæ*, for the number and variety of its possible variations.

Exterior of Cælocystis subglobosus.—In the Cedarville dolomite at Springfield, Ohio, two casts of the exterior of a globose Callocystid have been found, one of which was described and figured under the name *Callocystites sphaeroidalis* Fœrste (Ohio Jour. Sci. 17, 1917, p. 238, fig. 3; pl. 12, fig. 5). The second specimen (Plate II, Fig. 8 of the present paper) supplements the first by showing the pectinirrhomb on plates 1-5, and by showing definitely that the rays branched more than once. The entire theca must have been at least 4 mm. wider than the figure, the missing parts not being preserved in the specimen. The column was very large, considering the relatively small size of the theca. The surface of the first specimen is granulose, there being a tendency toward the arrangement of the granules in rows, about 6 or 7 granules in a length of 5 mm. On parts of the specimen the arrangement appears to be in diagonally intersecting rows; on other parts the rows take the form of parallel ridges, the transverse rows not being in evidence. On the second specimen the ornamentation consists of sets of parallel short ridges, not well brought out in the accompanying figure, the sets on different sectors of the plates being directed in different directions. The granules are not in evidence except as elevations irregularly dotting the crests of the ridges. It can not be determined from our present knowledge whether these specimens represent two distinct species.

In the collections in Walker Museum at Chicago University there is a black wax cast (Plate I, Figures 1 A, B) in the same tray with a specimen of *Cælocystis subglobosus*, numbered 22906, and labeled as coming from the Hindshaw collection, which was made at Chicago, Illinois.

Since the numbered specimen shows poor traces of the ambulacral system and the wax cast shows excellent evidence of the character of the latter it is assumed that it came from the same locality. The wax cast was made by pouring the wax into a natural mold of the exterior of a specimen, the cracks between the fragments of the matrix showing distinctly. It exposes the top of the specimen with its five ambulacral rays. The anal aperture is clearly defined, its margin protruding slightly. The right posterior ray branches just above the level of the anal aperture, the tips of the two branches reaching within 3 or 4 mm. from the attachment area of the column. The right anterior ray branches at about the same level, the tip of the right hand branch extending as far down as the others mentioned. The anterior ray is moderately distinct as far as its point of branching; its branches may have reached opposite sides of the pectinirhomb on plates 1-5. Only the proximal part of the left anterior ray remains. The left posterior ray is clearly defined for about two-thirds of the height of the theca downward, but a faint trace of its right-hand branch indicates that its tip reached within 5 mm. of the attachment area for the column. The right posterior ray shows clearly the short lateral branches of the food-grooves traversing the rays and their branches, but the attachment areas for the brachioles are not indicated. Lateral branches of the food-grooves, leading to the brachioles, are visible also on the right anterior and left posterior rays. Three or four lateral branches are seen on each side of the proximal or undivided parts of the rays, about 10 occurring on each side of the branches. The ornamentation of the surface is indistinctly preserved. The base of the specimen is not invaginated at all, as viewed from the exterior, but there is a faint quadrangular appearance there where the quadrangular margin of the deeply invaginated base of the cast of the interior should appear. It is evident that the invagination is a characteristic of the interior and is accompanied by an immense thickening of the thecal plates within this invaginated part.

This explains the absence of invagination also on the exterior of the base of the second specimen found at Cedarville, Ohio, here figured (Plate II, Fig. 8), which at first puzzled the writer.

The attachment area of the Chicago specimen just described is 9 mm. in diameter.

LOCALITY AND HORIZON.—From the Racine dolomite at Racine, Wisconsin, and in the Chicago area of Illinois. Also from the Cedarville dolomite at Cedarville and Wilmington, Ohio.

Both in the Cedarville dolomite of Cedarville, Ohio, and in the Racine dolomite of the Chicago area, there is a small cystid, about 15 mm. in diameter, which appears to be a new species of *Cælocystis*. The circum-oral plates or deltoids, forming the fourth row of the theca, are relatively large. The pectinirhombs on plates 12-18, and 14-15, and the plates surrounding the anal aperture are well defined, but the base is not well exposed in any of the specimens at hand.

5. *Lysocystites sculptus* (Miller).

Aethocystites sculptus Miller, N. Am. Geol. Pal., First App., 1892, p. 673, Fig. 1207; 18th Ann. Rep. Indiana Dep. Geol. Nat. Res., 1894, p. 264, Pl. 2, Fig. 2.

The types are preserved in the State Museum at Indianapolis, Indiana, and are supplemented by a well preserved specimen collected by Herrick E. Wilson at the type locality, St. Paul, Indiana; this supplementary specimen probably is in the Springer collection, in the U. S. National Museum, at Washington, D. C. All specimens were found in the upper layers of the Laurel formation. Only the exterior of the theca is well preserved, and this presents the following characteristics.

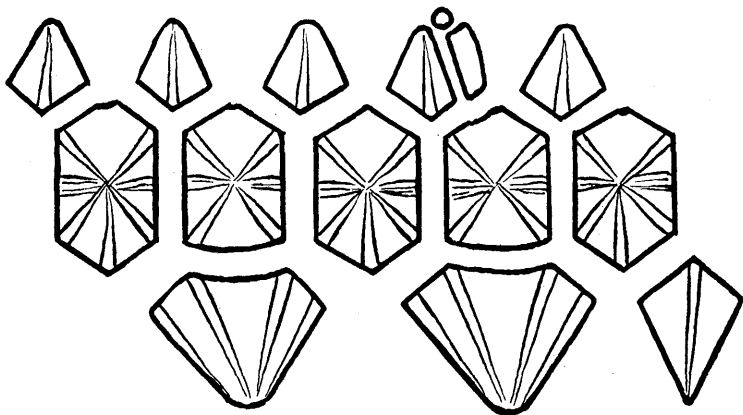


FIG. 3. Diagram showing arrangement of plates of *Lysocystites sculptus* (Miller). A composite drawing prepared from both the type and the specimen in the U. S. National Museum; not drawn to scale.

The basal series consists of three plates. Two of these are broad and are truncated above, evidently representing two plates each. The third plate is angular above. The genus evidently was derived from ancestral forms having five basal plates.

The second series consists of five plates, of which two are truncated at the base, all being angular at the top.

Alternating with the plates of the second series are five plates belonging to the third series. All of the latter are angular at the base and are medially ribbed. Beneath the anal aperture an elongated oblong plate appears to be inserted on the right side of one of the plates of this third series. The significance of this intercalated plate is not understood.

In each plate belonging to the second series, distally widening ribs radiate from the center to the upper and the two lower lateral corners, where they connect with corresponding vertical ribs on both the first and third series of plates. In addition, those three plates of the second series which are angular below have a fifth more or less distinct vertical rib connecting in each case with a rib following the sutures between the three basal plates. In the upper and lower quadrants of each plate of

the second series, vertical striae dominate; in the two lateral quadrants, horizontal striae dominate. In all cases the dominating striae are crossed transversely by finer striae.

Nothing is known of the column, although the facet for its attachment is present. Nor is anything definitely known regarding the summit of the theca in case of any of the specimens here under investigation.

The central part of the figure accompanying the original description consists of one of the hexagonal plates belonging to the second series. The nodes at the four extreme corners have weathered away and exposed some of the structure of the interior, but there is no evidence of pores connecting with this interior. The four exterior ridges connecting the central umbonal part of this plate with the nodes at its four extremities are well shown, but the fifth ridge, extending directly downward to the basal angle of the thecal plate, is poorly indicated. From this basal angle, in a complete specimen, the ridge continues downward along the sutures between two of the basal plates, narrowing toward the base, but this part of the specimen is not preserved in the figured type, and the figure here is misleading. The group of horizontal ridges dominating the plates of the second series at mid-height is not adequately demarcated from the striae above and below this horizontally ridged zone.

6. *Lycocystites nodosus* (Hall).

(Plate I, Figs. 11 A, B, C, D.)

Echinocystites nodosus Hall, 20th Rep. New York State Cab. Nat. Hist., 1868, p. 316, Pl. 12, Figs. 10, 11.)

Lysocystites nodosus Miller, N. Am. Geol. Pal., 1889, p. 259 (*Echinocystites* preoccupied).

Echinocystites nodosus was based on casts of the interior of the theca of a species described by Hall from the Racine dolomite at Racine, Wisconsin; later the generic name was changed to *Lysocystites*, *Echinocystites* being preoccupied. The type, numbered 2024, is preserved in the American Museum of Natural History in New York City. This type does not present clear evidence of the direction of the sutures between the plates, and therefore has been found of no service in unravelling the plate diagram of the species, nor in determining which is the top or bottom of the specimen. The clew to its structure was discovered by Arthur W. Slocom, who noticed that a specimen evidently identical specifically with *Lysocystites nodosus* formed the cast of the interior of a second specimen which was a cast of the exterior of a species having the same style of ornamentation as *Aethocystites sculptus* Miller, from the top of the Laurel limestone, at St. Paul, Indiana. Since the two specimens still were attached to each other, there was no possibility of error in the conclusion that they formed parts of the same specimen. With this clew as a guide it was found possible to orient several of the casts of *Lysocystites nodosus* belonging to Walker Museum at Chicago University. The best of these (Plate I, Figs. 11 A, B, C) is numbered 21815 and is from the type locality, Racine, Wisconsin. This has the following structure:

Casts of the interior of the theca.—At that end of the cast which corresponds to Figure 11 on Plate 12 accompanying Hall's original description of *Lysocystites nodosus*, three short narrow radiating ridges occur, and the outlines of three basal plates may be detected. Two of these plates are truncated above and the third is more rhomboid in outline and is angular at the top, as in the basal series of plates in *Aethocystites*. Along the upper margin of this basal series of plates are five more or less cuneate nodes, equidistant from each other, corresponding in position to the lower part of the sutures between the plates belonging to the second series. These cuneate nodes on the cast correspond in position to the lower series of strong angular nodes on the exterior of the theca. In addition to the five cuneate nodes there are three narrow vertical ridges, usually boldly defined, located at the upper end of the sutures between the three basal plates, and extending thence upward into the median part of those three plates of the second series which are angular at the base. All of these structures on the cast of the interior of *Lysocystites* correspond to salient features on the exterior of *Aethocystites*. Orientation of the specimen is facilitated by the fact that that one of the three short radiating ridges which is directed toward one of the nodes belonging to the lower series follows the median line of the narrow rhomboid basal plate. Passing from the node at the top of this plate two nodes toward the left, and thence vertically upward, the anal aperture will be found at the top of the third series of plates, slightly toward the right of this vertically directed line.

In Hall's Figure 11, the base of the theca has been interpreted as the summit. The specimen is so oriented as to place the rhomboid basal plate at the top of the figure. The narrow vertical ridge at the lower end of the figure was determined incorrectly as the ovarian aperture; no aperture of any kind being present here. The two other corresponding vertical ridges, at the upper end of the sutures on the right and left of the rhomboid plate are not clearly defined in the cast figured by Hall, and are not indicated in his figure. Figure 10 represents the type in an inverted position, with the supposed ovarian aperture occupying the middle of the upper part of the figure.

Returning to the Walker Museum specimen described above, a second series of cuneate nodes is located immediately above the first series, at the top of the second series of plates, but with the pointed end directed in the opposite direction. They locate the upper series of nodes visible on casts of the exterior of *Aethocystites*. The truncated ends of both the lower and upper series of cuneate nodes are separated more or less by a transverse groove from the rest of the nodes. If any pores connecting the plates are present they might be searched for here. The specimens at hand present no evidence on this subject. The upper or third series of plates can be diagrammed readily so as to conform to the system worked out for *Aethocystites sculptus*, although the suture lines are indicated only faintly.

After studying specimen number 21815, just described from the Walker Museum collections, other specimens of casts of the interior of *Lysocystites nodosus* become readily intelligible. In the Walker Museum

of Chicago University, for instance, there are five Racine specimens of *Lysocystites nodosus*, numbered 18943, all casts of the interior, in different states of preservation. Using the entire series, practically all the details already described in the case of specimen number 21815 can be made out. They differ from the latter chiefly in the appearance of the two series of nodes (Plate I, Fig. 11 D). These are not cuneate in outline and are not crossed at what corresponds to their truncated ends by a transverse groove. Moreover, these specimens are smaller in size than the one numbered 21815, but in all other features they so closely resemble the latter as evidently to be congeneric. Since there is no question of specimen number 21815 being congeneric with *Aethocystites*, the specimens numbered 18943 belong here also. The latter, however, are identical in character with the type of *Lysocystites nodosus*, so that the latter also evidently is congeneric with *Aethocystites*.

Exterior surface.—In the preceding lines it was mentioned that the cast of the interior of *Lysocystites nodosus* had been found by Arthur W. Slocom forming the interior of a specimen of *Aethocystites*. At the time of my visit to Chicago, this specimen was not accessible, but another specimen of *Aethocystites*, presenting the cast of the exterior, found in the Cedarville dolomite at Wilmington, Ohio, forms number 2193 of the Walker Museum collection at Chicago University, and evidently has some bearing on the subject since the Cedarville dolomite carries a typical Racine fauna. This cast of the exterior shows the very characteristic surface markings of *Aethocystites*, including the nodes at the four angles of the plates of the second series. Only two plates of the second series are preserved, one of them truncated at the base, the other pointed. The original height of this Wilmington specimen is estimated at 19 mm.; the height of the Racine specimen numbered 21815, the first one described here, is about the same, but the specimen appears more rotund.

LOCALITY AND HORIZON.—In the type area, *Lysocystites nodosus* is known definitely only from Racine, Wisconsin.

REMARKS.—It is possible that there are two species of *Lysocystites* in the Racine dolomite of Wisconsin. In that case, the term *Lysocystites nodosus* must be restricted to forms like the type, in which the nodes at the four corners of the plates of the second series are not conspicuously cuneate in outline, and do not have their truncated ends similarly separated from the remainder of the nodes by transverse grooves. Specimen 21815 possibly belongs to a second species, and the cast of the exterior of *Aethocystites*, numbered 2193, from Wilmington, Ohio, may not belong to either of these species. For the present, however, all are regarded as belonging to a single species, the term *Lysocystites nodosus* covering all the forms here discussed.

USE OF TERM *LYSOCYSTITES*.—Since the generic name *Lysocystites* was proposed in 1889, five years earlier than *Aethocystites*, the latter is abandoned.

RELATIONSHIP.—*Lysocystites* was referred by Bather (The Echinoderma, 1900, p. 70) to the *Cryptocrinidæ*, the sole family of the *Aporita*. The relationship is even closer than hitherto suspected. In *Cryptocrinus*, from the Ordovician of Russia, there are three basal plates formed by the fusion of two pairs of the original five, the unfused plate being in the right anterior interradius. Alternating with the five original basal plates is a second series of five plates, all free from each other and hexagonal in outline, followed in turn, in alternating order, by a third series of five plates, subpentagonal in outline. The anus lies between two plates of the third series, separated from the nearest plate of the second series by a small supplementary plate. In all of these features *Cryptocrinus* closely resembles *Lysocystites*. The latter differs chiefly in the more elevated position of the anal aperture, the latter being located at the top of the third series of plates rather than between two of the latter. None of the plates of the fourth series, nor any of the tegmental plates at the extreme summit of the theca, are known in case of *Lysocystites*.

Holocystites Hall.

Holocystites Hall, 20th Rep. New York State Cab. Nat. Hist., 1868, p. 311, 380.
Genotype: *Holocystites cylindricus* Hall.

Megacystites Hall, Addenda of preceding report, p. 380. Substitute for *Holocystites*.

Trematocystis Jaekel, Stammesgeschichte der Pelmatozoen, 1899, p. 414.
Genotype: *Holocystites subglobosus* (Miller), Pl. 4, Fig. 2.

Holocystites of Hall.—The genus *Holocystites* was founded by Hall on six species of cystids which agreed in having the plates arranged in more or less alternating transverse or more or less alternating vertical rows, the plates of the more primitive species showing a marked tendency toward a predominance of hexagonal outlines. The oral aperture was terminal and the anal aperture was eccentric but only a short distance away from the oral one. The arms evidently were not recumbent and there was no trace of their former location.

The first three species described in the accompanying text agreed in being distinctly elongated in a vertical direction, the first species of this series being called *Holocystites cylindricus* on this account. In reality, three forms are figured under this name, of which figure 4 on plate 12 is regarded here as the type. The second described species, *Holocystites alternatus*, differs from the first by the intercalation of numerous supplementary plates between the transverse rows of more primitive plates.

The third species, *Holocystites abnormis*, differs from both the preceding in having the intercalated plates inserted in a more or less transverse row beneath the fourth series of plates, counting downward from the top of the theca. Of these three species, *Holocystites cylindricus* is regarded as the genotype.

The other three species, *Holocystites winchelli*, *H. ovatus*, and *H. scutellatus*, are oval or approximately spherical in form, and to these must be added *H. sphaericus* described by Winchell and Marcy from the Racine of the Chicago area, and *H. jolietensis* described by Miller from the Niagaran of Joliet, Illinois.

Holocystites of Miller.—The 40 so-called species of *Holocystites* described by Miller from the Osgood limestone of Indiana, one species being cited as though from the top of the Laurel limestone in the Waldron area, all agree in having the plates pierced by diplopores, the pores of each pair being connected just beneath the surface of the plates by peculiar channels frequently resembling the Greek letter Omega. Both the oral and the anal aperture have polygonal margins, the polygonal outline of the oral aperture being accentuated by the food-grooves leading from each angle of this aperture to the proximal end of a facet, each facet evidently serving originally for the support of a brachiole, since the food-groove indents the margin of each facet, although no brachioles ever have been found. At least 10 of these species had 5 brachioles, 2 more species probably having the same number. At least 16 species had 4 brachioles, 5 additional species probably having the same number of brachioles.

Holocystites amplus group.—Of the remaining 7 species described by Miller, 5 may belong to the group typified by *Holocystites amplus*. In this group, 3 food-grooves, narrowing distally, lead from angles of the oral aperture to large facets for the support of brachioles. The nearest relative to *Holocystites amplus* appears to be *Holocystites adipatus*, which preserves one of the long, rapidly attenuating food-grooves; *Holocystites tumidus* resembles *H. adipatus* in shape, and *H. ventricosus* may belong here also. *Holocystites gyrinus* agrees apparently in having three main food-grooves, but the latter do not attenuate strongly distally as in *H. amplus*, and both the left and left anterior food-grooves appear to bifurcate on reaching the facets, as though two arms were supported on a single protuberance in each case. The facet at the end of the right-hand ray is not preserved. Unfortunately, the upper end of the theca has been crushed from front to rear, producing the tantalizing conviction that some extremely interesting structure is here obscured. In the species with 3 main food-grooves, the length of these grooves is so much greater than in other species that there is a possibility of their belonging to a distinct genus. It is not certain, however, that *Holocystites gyrinus* belongs to the same group as *Holocystites amplus*, although the limitation of the food-groove system in both cases to 3 main strongly divergent rays suggests such a relationship.

NUMBER OF ARMS.

The absence of arms on all known Osgood forms referred to *Holocystites* suggests that the latter were stiff and readily broken off, as in the case of the arms of the very different genus *Comarocystites*. The very distinct food-grooves are sufficient evidence of arms on the protuberances at their ends, especially in view of the fact that the food-grooves indent the margins of these protuberances.

There is no evidence of generic differences between species having 5 arms and those having 4 arms. Among species with 4 rays there are both smooth forms with the quadrangular margins surrounding the central oral aperture distinctly delimited, and coarsely papillate forms with the corresponding quadrangular margins rendered more indistinct by the presence of the papillæ. Moreover, there are variations in the length of the theca and in the arrangement of the plates which can not be brought into co-ordination with any oral structure.

ANAL APERTURE OF HOLOCYSTITES.

One distinct advance in our knowledge of the anal aperture has been made. This consists in the fact that the outline of the anal aperture in all cases is polygonal, usually either pentagonal or hexagonal, and covered with a pyramid consisting of as many triangular plates as there are sides to the aperture. Many of the specimens show the facets for the attachment of the plates forming the pyramid, but the pyramid itself has been observed in only one case, namely, in an undescribed species of *Holocystites*, of the elongate type, as in *H. alternatus*, which is numbered 10965 in Walker Museum of Chicago University, is labeled as coming from Jefferson County, Indiana, probably is from the Osgood formation, and retains distinctly 2 of the 5 plates belonging to its anal pyramid. These plates are triangular, almost equilateral in form, and are still in position. This specimen had 4 arms. A study of the material accessible at Chicago University led to the conclusion that no classification could be based on differences in the number of plates forming the anal pyramid. On the contrary, this number appeared to vary from 5 to 6 in the same species in several cases.

A study of the form of the theca and of the arrangement of the plates of the theca also failed to show any generic differences but led to other significant observations.

HOLOCYSTITES CYLINDRICUS GROUP.

For instance, there is a group of Osgood species, characterized by their elongate form and by the more or less definite arrangement of their plates, which closely resemble the group of elongate Racine species: *Holocystites cylindricus*, *H. alternatus* and *H. abnormis*. Corresponding to *H. cylindricus* is *H. canneus*, with 5 arms, although a few plates are irregularly inserted. Corresponding to *H. alternatus* are *H. bacculus* and *H. perlongus*, each with 5 arms. *H. plenus* with 5 arms probably also belongs here. Of the less elongate, more ovate species having supplementary plates inserted very much as in *H. alternatus* there are *H. splendens* with 5 arms, and *H. faberi*, *H. parvulus*, and *H. spangleri* with 4 arms. *H. abnormis* appears to be represented in its oblique form by *H. colletti*. After studying these more elongate Osgood forms it seems impossible to avoid the conclusion that we have here a series of species congeneric with the genotype of *Holocystites*. Unfortunately, the Racine species are known at present chiefly from casts of the interior of the theca, presenting little evidence of the structure of the exterior. The granulose surface of many of these Racine specimens is formed by the fillings of the pores traversing the thecal plates. While these pores appear to be arranged in pairs, no entirely conclusive evidence has been found. No trace of the Omega-like connections between the pores has been noticed. The outlines of the oral and anal apertures are not preserved with sufficient distinctness in the specimens at hand. Finally, insurmountable obstacles result from the entire absence of any knowledge of the food-grooves and of the supports for the arms. This is due to the fact that collectors preserve only the casts of the interior of the theca but make no prolonged search for impressions of the exteriors. The latter usually occur only in large rocks, inconvenient to carry home, and in a fragmentary condition are not readily recognized as of value.

HOLOCYSTITES WYKOFFI GROUP.

In contrast to the elongate Osgood species of *Holocystites* is a group of globose forms, usually supported by a broad, flat base, the flattened area including several of the thecal plates. On one side of the specimen the plates have an elongate hexagonal form and are arranged in more or less transverse rows, while on the

opposite side of the same specimen this arrangement in rows may not be so evident. This arrangement is found in *H. wykoffi* and *H. sphaeroidalis*, with 5 arms, to which *H. madisonensis* probably is closely related, with *H. subrotundatus* less certain. This tendency toward the arrangement of the plates in transverse rows is shown also by numerous ovate forms with coarsely papillate surfaces, having 4 arms, and including *H. affinis*, *H. benedicti*, *H. ornatissimus*, *H. papulosus*, and *H. subovatus*. Species of this type can not be differentiated generically from the smoother ovate forms, with 4 arms, in which there is no very obvious arrangement of the plates in transverse rows, as in *H. commodus*, *H. globosus*, *H. gorbyi*, *H. hammelli*, *H. indianensis*, *H. parvus*, *H. rotundatus*, *H. scitulus*, and *H. subglobosus*.

The studies here outlined have led to the conclusion that the importance attributed to the types of species has given rise to certain disadvantages as well as advantages. Although numerous specimens of *Holocystites* were collected formerly in the Osgood formation of southeastern Indiana, only the types were highly valued and have gone into the important collections. The other specimens became objects of trade and sale and have become practically lost to science. Hence, from the meager representatives of any one species it frequently is impossible to determine the range of variation in form, arrangement of plates, outline of oral or anal aperture, or the surface ornamentation. While the writer is convinced that the species described by Miller number only about one-fourth as many as indicated by the list of names, the material for more exact discrimination is lacking.

THE TERMS HOLOCYSTITES, MEGACYSTIS, AND TREMATOCYSTIS.

The generic name *Trematocystis*, proposed by Jaekel rests on the Osgood species *Holocystites subglobosus*. This is one of the smoother species with 4 arms, with a sharply angulate quadrangular border around the oral aperture, and with the plates more or less arranged in transverse rows, but not conspicuously elongated in a vertical direction along the lower of these rows. As far as may be judged from our present knowledge of the various Osgood forms, there is a considerable probability that this term eventually must be discarded for either *Holocystites* or *Megacystis*.

STUDIES BY BATHER.

In last year's numbers of the Geological magazine Bather has added greatly to our knowledge of the Osgood forms of *Holocystites*. In these numbers he has elaborated with his usual acumen our knowledge of this genus, and has accompanied the same with numerous drawings which illuminate every phase of its structure.

7. *Holocystites alternatus* Hall.

(Plate IV, Figs. 1, 2, 3, 4, 5, 6.)

Holocystites alternatus Hall, 20th Rep. New York State Cab. Nat. Hist., 1868, p. 312, Pl. 12, Fig. 9; Pl. 12a, Fig. 6.

Holocystites alternatus Foerste, Ohio Jour. Sci., 17, 1917, p. 233, Pl. II, Fig. 4.

In the type of *Holocystites alternatus* (Plate IV, Fig. 6) there are two sets of plates: a primary set, conspicuously larger in size, arranged in transverse rows with 8 plates in each row, and a distinctly smaller set inserted in transverse rows between the transverse rows of primary plates. Three of the rows of primary plates are lettered A, B and C; a fourth row, unlettered, occurs almost at the very base of the specimen. Between rows A and B, and between B and C, secondary plates were inserted at all points where three sutures met, resulting in octagonal outlines for the primary plates and pentagonal outlines for the secondary intercalated plates, the unpaired angle of the latter being directed alternately upward and downward. Between C and the lowest row of primary plates there was inserted first a secondary series arranged in transverse order, and above and below the latter a tertiary series was added, resulting in a very elongate theca.

A somewhat similar arrangement is noted in a specimen from the same locality, Racine, Wisconsin, numbered 839, and preserved in the Public Museum of Milwaukee (Plate IV, Fig. 1). The arrangement of the intercalated plates immediately below some of the plates of series C is very similar, but the interpretation of the lower plates requires the intercalation of three transverse rows of secondary plates, all at about the same time.

Three specimens are figured from the Cedarville dolomite at Cedarville, Ohio (Plate IV, Figs. 2, 3, 4). All of these are noteworthy for the simplicity of the plate system between rows C and D, there being only a single transverse series of secondary plates, with a few scattered, inconspicuous, tertiary ones.

In a specimen from Wilmington, Ohio, the intercalation of secondary and tertiary plates has been carried to an extreme, even the primary plates of row B being distinctly separated.

This Wilmington specimen is remarkable also for the excellent preservation of the lines of growth on the thecal plates. The most conspicuous evidence of growth along the margin of the larger plates is formed by a flattened border, from a millimeter to a millimeter and a half in width, above which the central part of each plate rises mod-

erately, but rather abruptly. From these zones it is evident that when some of the larger plates were smaller, some of the still smaller plates might have been absent altogether. In still earlier stages of growth only those plates here called primary probably were present. If this view be correct, then such species as *Holocystites cylindricus* and *Holocystites abnormis* might be regarded as retaining their primitive characteristics even in old age, and young specimens of species which in older age resemble *Holocystites alternatus* might be expected to resemble *Holocystites cylindricus* in their earlier stages of growth.

8. *Holocystites greenvillensis* Foerste.

Holocystites greenvillensis Foerste, Ohio Jour. Sci. 17, 1917, p. 203, Pl. 9, Figs. 3 A, B, C; Plate 10, Fig. 8.

This species, described from the Cedarville dolomite four and a half miles east of Greenville, Ohio, is an excellent example of a small form of *Holocystites* preserving its primitive characteristics, namely, about five transverse rows of plates, each row consisting of about 8 plates, the successive rows alternating with each other.

9. *Allocystites hammelli* Miller.

(Plate I, Figs. 13 A, B.)

Allocystites hammelli Miller, N. Amer. Geol. Pal., 1889, p. p. 222, Fig. 242.

Basal part, for a height of 5 mm., rapidly expanding from a width of 2.5 mm. to 6 mm.; bottom broken off; in place of a column there may have been merely an attachment area as in *Holocystites*. This basal part is followed by a circlet of 7 plates, the line of separation between two of these being indistinct. The next circlet contains 8 plates of larger size; in addition to this there are 3 pairs of accessory plates, vertically arranged, separating adjacent plates from each other, and to this is added another accessory area too poorly defined to be deciphered. The following or third circlet also consists of 8 plates of larger size; in addition there are accessory plates at 7 of the 8 intervening sutures; at 5 of these sutures the accessory plates are known definitely to be arranged in pairs, one plate directly over the other; at the other two sutures the same structure may exist but it is not decipherable. The following or fourth circlet also consists of 8 plates of larger size; in addition there appear to be pairs of accessory plates at 3 of the intervening sutures, and single accessory plates at the lower ends of apparently 4 of the remaining sutures. The anal aperture rests on the upper margin of two of these plates of the fourth circlet and is enclosed, laterally at least, by plates of the fifth circlet. The latter circlet consists of at least 7 plates, the two in contact with the anal aperture being of exceptional width, the remaining 5 being tall rather than wide. If there is a sixth circlet of plates, its presence can not be detected in the type specimen.

Surmounting the entire specimen, at least in its present condition, is a protuberance 2 mm. in height, constricted at the base, with a pentagonal outline at the top, with a width of 5.6 mm. between the right anterior and left anterior angles, and a diameter of 4 mm. from

the anterior angle to the posterior margin. From the five angles ridges extend toward the center of the rather flat top of the protuberance. These 5 ridges are not sharply defined and their actual structure remains obscure. There is no evidence of the presence of food-grooves. As far as may be determined from the single specimen at hand, the oral aperture may have been covered by a pyramid of 5 plates, somewhat as in *Sphaeronis, globulus* Angelin, or as in *Glyptosphaera leuchtenbergi* Volborth, from the Ordovician of the Baltic areas of Russia.

Between the oral and the anal apertures there is a transverse ridge, interpreted as locating the madreporite. No gonopore can be detected.

The margin of the anal aperture protrudes slightly. Its outline is slightly elliptical, rather than circular, the diameters being 3 and 4 mm. The inner margin appears to be rhomboid with the major axis in a lateral direction, suggesting an anal pyramid of 4 plates, but the evidence is not clear.

Surface granulose, with the granules varying from slightly more to slightly less than a millimeter apart. Under a lens, very minute granules, not visible to the unaided eye, appear in great numbers. Where the surface of the plates has been removed in cleaning the top or fifth circlet of plates, there appear to be slight color changes suggesting the presence of the Omega-like ornamentation of the worn surfaces of the plates of *Holocystites*. Here, again, the evidence is not clear.

LOCALITY AND HORIZON.—From the Osgood formation on Riker's Ridge, about 4.5 miles northeast of Madison, Indiana. Type numbered 6006 in Walker Museum of Chicago University.

REMARKS.—Were it not for the oral protuberance, this specimen would be regarded readily as a typical species of *Holocystites*. It differs in plate system from such a form as *Holocystites greenvillensis* chiefly in the presence of numerous accessory plates. It is regarded as belonging to the same family. However, the anomalous oral protuberance is sufficient to establish it as a distinct genus.

10. *Gomphocystites indianensis* Miller.

(Plate I, Figs. 5 A, B.)

Gomphocystites indianensis Miller, N. Amer. Geol. Pal., 1889, p. 249, Fig. 319.

The upper, more globular part of the theca evidently has been compressed, but its outline, as seen from above, may have been distinctly elliptical even before compression. This is suggested by the relatively straight direction of the anterior and right anterior food-grooves along part of their paths, as seen in the figure accompanying the original description of the species. It is suggested also by the parallel direction of the straight parts of these food-grooves and by the angular curvature of the right anterior food-groove at mid-length. It will require additional specimens to determine how much of the elliptical form of the

theca is due to compression. The height of the globular part of the theca is about 20 mm. At the base it appears to have narrowed strongly to a short stipe, probably not over 15 mm. in length, although this part of the theca is not preserved.

The oral aperture is at the base of a deep, laterally elongated, triangular pit, the anterior food-groove departing from the anterior angle of this pit, the right anterior and right posterior food-grooves departing from the angle on its right, while the left anterior and left posterior food-grooves separate from each other at a point about a millimeter from the left angle of the pit. The most characteristic feature of the species consists in the relatively great width and depth of the food-grooves and their almost V-shaped cross-section. Along the proximal half of the length of the food-grooves their width equals about 1.5 mm. Along the sides of the food-grooves there are depressions or grooves which may locate the sutures between the bordering plates. If they represent branches of the food-grooves, then it should be observed that they lead to no facets for brachioles. Parts of the surface are so well preserved that the absence of any evidence of the presence of brachioles should be emphasized.

The food-grooves complete more than half of a circuit, the distal end reaching the lower side of the globular part of the theca. The distal end of the left anterior food groove curves upward toward the anterior food-groove and becomes parallel to the latter again for a short distance, as indicated in Fig. 5B on Plate I, and also in the figure accompanying Miller's description. The anal opening is circular and 3 mm. in diameter. No trace of the anal pyramid or of the small plates covering the food grooves remains.

The surface is strongly and irregularly granulose, most of the granules being about one millimeter, or a little less, distant from each other. Where the surface is worn, there are diplopores, the individuals of each pair being less than half a millimeter from each other. Where the surface is not worn, there is no trace of these diplopores.

LOCALITY AND HORIZON.—From the Osgood formation in Jefferson County, Indiana. Specimen numbered 6019 in the Walker Museum of Chicago University.

11. *Gomphocystites* sp.

(Plate III, 2 A, B.)

Theca depressed globular, narrowed strongly at the base to a short stipe probably a little over 5 mm. in length. Along part of the globular portion of the theca the sides appear flattened, but this may not be a constant feature. There is no tendency toward straightening of any part of any of the food-grooves as in the case of *Gomphocystites indianensis*. The distal ends of these food-grooves reach the lower part of the flattened sides of the theca. The distal end of the left anterior food-groove probably curves upward toward the anterior food-groove, as in *Gomphocystites indianensis*. Along part of the anterior food-groove, several

short grooves branch off from the main food-groove and terminate abruptly near the middle of thecal plates, but without any evidence of facets for the support of brachioles. Compared with *Gomphocystites indianensis*, the surface is papillose rather than granulose, the papillæ being about 1.5 mm. or more distant from each other. The width of the food-grooves is about a millimeter or slightly less, and their cross-section is shallow U-shaped, rather than deeply V-shaped.

LOCALITY AND HORIZON.—From the base of the Louisville limestone, immediately over the Waldron shale, at the railroad cut two miles east of Anchorage, Kentucky.

REMARKS.—While this Louisville specimen is regarded as belonging to a new species, the state of preservation of the specimen figured makes the latter undesirable as a type.

12. *Gomphocystites bownockeri* Sp. nov.

(Plate III, Figs. 1 A, B; Plate I, Figs. 6 A, B; 9 A, B; Plate II, Figs. 9 A, B.)

Ohio specimens.—Thecas obliquely compressed, originally probably depressed globose, rapidly narrowed at the base to a short stipe, probably not over 10 or 15 mm. in length. Oral aperture elongated transversely, about 4 mm. wide and 3 mm. long from front to rear along its median line. Thecal plates varying in size; those along the outer margin of the food-grooves tending to be smaller, more or less elongated at right angles to the food-grooves, the intermediate sutures having the same direction, the resulting appearance being that of oblong bodies packed together laterally. Usually only that row of plates which is in immediate contact with the food-groove presents the laterally compressed appearance in a striking manner, but a second row frequently offers a similar appearance along a part of its length and in a less obvious manner. In the spaces between those rows of plates which are adjacent to the food-grooves there are other plates varying considerably in size and some of these plates are much larger than any forming the rows. Larger plates occur also along the lower part of the theca, including the stipe.

The anal aperture is 4 mm. in diameter, and 3 mm. distant from the nearest part of the oral aperture. The food-grooves extend at least below mid-height of the globular part of the theca, and probably reach its lower part. The food-grooves are faintly impressed on the type specimen, the latter being regarded as a cast of the interior of the theca.

The plates show marginal depressed areas, with central raised parts, interpreted as evidences of marginal growth. The marginal depressed bands of the larger plates are about 1 mm. in width, and those of the smaller plates are narrower, suggesting the later intercalation of the smaller plates.

LOCALITY AND HORIZON.—From the Cedarville dolomite at Cedarville, Ohio. Type, numbered 8736A, in the Museum at Ohio State University. A second specimen, 8736B, 40 mm. in width, shows similar features.

Racine specimens.—*Gomphocystites bownockeri* occurs also in the Racine dolomite of the Chicago area. Several specimens, numbered 22944, are preserved at Chicago University. The one marked 22944A shows the row of laterally compressed plates, along the lower side of one of the food-grooves, very well. The thickness of the thecal plates is almost 2 mm. The middle layers of most of the plates have weathered away, leaving the fillings of some of the diplopores exposed in the form of columns. The exterior layers of a sufficient number of these plates has been preserved to indicate that the food-grooves are relatively narrow, only a millimeter or less in width, but rather sharply impressed; on casts of the interior of the theca they are only faintly indicated. At one point, several short lateral branches of the food-grooves seem to be present.

In a specimen numbered 4523 at the U. S. National Museum, short lateral grooves branch off diagonally from the lower side of the main food-grooves and terminate at small facets, evidently for the support of brachioles. The combined length of the branches with the terminal facets is 2 mm. Along the proximal part of the main food-grooves 5 facets occur in a length of 10 mm. No clearly defined lateral grooves and facets were noticed along the upper side of these main food-grooves.

Surface ornamentation.—Two specimens of *Gomphocystites* from the Chicago area, numbered 22943 at Chicago University, present impressions of parts of the exterior surface. One of these consists of the impression of the top of a specimen, and shows food-grooves, a relatively coarsely papillate surface, and numerous diplopores, the pores of each pair averaging about half a millimeter or less apart. The second specimen retains the impression of the attenuate basal stipe, 15 mm. long, and also the impression of part of the lateral wall of the globose part of the theca. The tips of the food-grooves evidently reach the lower slopes of the globose part of the theca. The striking feature of this specimen is its strongly papillate ornamentation, the papillae on the upper surface of the theca frequently being 1.5 to 2 mm. apart, while those on the stipe may be one millimeter or even less distant from each other.

Food-groove system.—The food-grooves are deeply incised into the outer surface of the theca. Three primary branches leave the oral aperture. Of these, the anterior branch remains undivided; the right branch divides slightly over one millimeter from the center of the oral aperture; the left branch divides at a distance of about 2 mm., the resulting total being 5 branches. The width of the food-grooves is one millimeter or less.

Variation in the form of the theca.—Two of the specimens from the Chicago area, numbered 22944 at Chicago University, namely B and C, are nearly globular rather than depressed globular in form, but present the same rows of laterally compressed small plates along the lower side of the food-grooves as in *Gomphocystites bownockeri*. Specimen 22945 (Plate I, Figs. 9 A, B) from the same area, differs merely in its more elongate form. In all of these specimens the tips of the food-grooves extend practically to the base of the more globular part of the theca.

One of the specimens found at Cedarville, Ohio (Plate II, Figs. 9 A, B) also presents a globose form, but the food-grooves apparently extend only half way down the globose part of the theca. It consists of a rather poorly preserved cast of the interior of the theca.

REMARKS.—Hall described only two species of *Gomphocystites* from the Racine dolomite, *Gomphocystites glans* and *G. clavus*, both from Racine, Wisconsin. The type of the genus is *Gomphocystites tenax*, from Lockport, New York. All of these species described by Hall have long stipes, while all described in the present paper have short stipes.

Narrawayella Gen. nov.

Cyclocystoides.—The genus *Cyclocystoides* was based by Billings and Salter (Geol. Surv. Canada, Dec. 3, 1858, p. 86) on *Cyclocystoides halli* Billings. The conspicuous part of this species, as far as known, consists of a ring of relatively large plates, surrounded by a peripheral margin of small imbricating plates. The proximal half of the large plates is strongly elevated above the distal half; it is evenly convex, and covered with low granules. The distal half of each plate usually shows two spoon-shaped depressions. The outer edge of the proximal half of the large plates is under-cut, and this under-cutting extends backward into proximal half of the plate as a funnel-shaped pit, but it is not definitely known whether this pit continues in the form of a pore entirely through the plate.

In American strata, 6 species having this type of structure are known. These are: *Cyclocystoides anteceptus* Hall, from the Black River of the Escanaba River; *Cyclocystoides halli* Billings, from the Curdsville member of the Trenton in Canada; *Cyclocystoides salteri* Hall, from the Trenton near Saratoga Springs, New York; *Cyclocystoides bellulus* Miller and Dyer, from the Fairmount at Cincinnati, Ohio; *Cyclocystoides magnus* Miller and Dyer, from the Fairmount at Morrow, Ohio; and *Cyclocystoides huronensis* Billings, from the Richmond on Rabbit Island, in Lake Huron.

None of the other seven described American species referred to this genus are known to have the structure found in *Cyclocystoides halli*. There is no evidence for regarding them as true species of *Cyclocystoides*. In fact, they differ not only from that genus but also among each other.

Narrawayella.—One of these distinct groups is typified by *Cyclocystoides cincinnatiensis* Miller and Faber, from the Corry-

ville member of the Maysville formation at Cincinnati, Ohio. In this species the plates are coarsely pitted. *Cyclocystoides nitidus* Faber, from the Corryville member, near Transit, Ohio, also is coarsely pitted and may be the same species, differing only in having 24 instead of 30 plates in the ring of large plates. *Cyclocystoides mundulus* Miller and Dyer, probably from the Corryville at Morrow, Ohio, with 32 plates, probably belongs to the same group. Raymond describes and figures a similar specimen of the same type (Bull. Victoria Memorial Museum, 1, 1913, p. 28, Fig. 3, Pl. 3, Fig. 4) from the *Prasopora* zone of the Trenton in the Axe Factory quarry, at Hull, Quebec. This specimen is in the Narraway collection and is described as having the large plates covered with small pits between which are rounded inosculating ridges. For this group of pitted species, typified by *Cyclocystoides cincinnatiensis*, the term *Narrawayella* is proposed, in recognition of the great service to paleontology rendered by Mr. J. E. Narraway during his life as a collector of fossils in the rich area surrounding Ottawa, in Canada. For the species described and figured by Raymond, the name *Narrawayella raymondi* is offered. In this group of species the outline of the large plates is cuneate rather than quadrangular, and there is no evidence of spoon-shaped ornamentation on the distal halves of the plates.

Cyclocystoides minus Miller and Dyer and *Cyclocystoides parvus* Miller and Dyer, both from Morrow, Ohio, the first with 19 plates, the second with 26 plates in the main ring, are not sufficiently understood but may belong to the same group as the preceding. I do not know on what authority these species are cited from the Richmond.

Agelacrinus arm.—A remarkable specimen figured by Miller and Faber (Jour. Cincinnati Soc. Nat. Hist., 15, 1892, p. 85, Pl. 1, Figs. 13–15), from the hilltop at Cincinnati, Ohio, as probably a fragment of *Cyclocystoides magnus*, consists of a fragment of either *Agelacrinus cincinnatiensis* or *Agelacrinus pileus*, exposing both the upper and lower surface of one of the rays, and some of the adjacent plates. The floor plates of this ray overlap each other distally, and along the margins of the floor-plates are seen the basal extensions of the lateral covering plates, as in ray 3 of Figure 5A, Plate 1, accompanying my paper on *Agelacrinidae*, in the Bull. Denison Univ., 17, 1914, pp. 399–487. See also volume 18, 1916, pp. 340, 341.

Savagella Gen. nov.

Recently Savage described a remarkable form from the Orchard Creek shale, near Thebes, Illinois, under the name *Cyclocystoides ornatus*. The large plates forming the conspicuous ring are similar to those of typical *Cyclocystoides* in being quadrangular in shape, but here the similarity ends. Along their upper surface the plates are radially grooved, their inner face is vertical, and their lower surface is convex, their radial cross-section being subtriangular. There is no structure comparable with the spoon-like ornamentation of typical *Cyclocystoides*, moreover the steep inner face of the ring-plates must have been correlated with an altogether different structure of the theca interior to the ring. Therefore the new generic term *Savagella* is proposed, with this species as the genotype.

Cyclocystoides illinoisensis.—A fourth generic type is represented by *Cyclocystoides illinoisensis* Miller and Gurley, from the same locality and horizon as *Cyclocystoides ornatus*. The ring plates of this species are flattened, without conspicuous ornamentation, and their radial cross-section has a flattened elliptical form. For this fourth generic type no new name is provided at the present time although it is believed that it will prove distinct when better understood.

These four genera—*Cyclocystoides*, *Narrawayella*, *Savagella*, and the unnamed genus having *Cyclocystoides illinoisensis* as a type—are included in the family *Cyclocystoididae*, proposed by S. A. Miller (Jour. Cincinnati Soc. Nat. Hist., 5, 1882, p. 223), with *Cyclocystoides* as the typical genus around which the others are grouped.

In proposing these new names it is fully realized that the structure of these peculiar organisms is not fully understood. It is believed, however, that the first step to their understanding is to note that the species hitherto grouped under the single term *Cyclocystoides* differ greatly in structure and probably represent several distinct but closely related genera.

13. *Savagella ornatus* Savage.

(Plate I, Fig. 18.)

Cyclocystoides ornatus Savage, Trans. Illinois Acad. Sci. 10, 1917, p. 265, Pl. 2, Fig. 1.

Type: Disk 18 by 20 mm. in diameter. Submarginal ring, consisting of 20 plates. The individual plates are about 1 mm. long in a radial

direction, and 2.5 mm. wide in a direction parallel to the circumference of the theca. Their radial cross-section is subtriangular. Along their inner faces they are abruptly vertical. Their upper faces curve downward with even convexity as far as mid-height on the outer margin of the plates; these upper faces are crossed radially by low ribs, usually five, sometimes four, on each plate. The lower faces also are moderately convex. The narrow intervals between the plates are occupied by a darker substance which, originally, may have been flexible, permitting the submarginal ring to be flexible.

The submarginal ring of plates is bordered exteriorly by a marginal band of imbricating plates. Those in contact with the ring usually equal or slightly exceed 1 mm. in width, sometimes attaining a width of 1.5 mm.; they appear to be short but wide, with broadly convex free margins. The other plates are successively narrower, those at the margin of the theca usually being about half, or slightly more than half, of a millimeter in width; they are longer than wide.

The basal part of the specimen, within the submarginal ring, appears to be formed by numerous plates from less than one millimeter to slightly over one and a half millimeters in diameter. These are irregularly convex, so as to produce moderate depressions at numerous points. Their margins are too poorly defined to determine whether there is any definite system in their arrangement.

LOCALITY AND HORIZON.—From the Orchard Creek shale, near Thebes, Illinois.

Specimen figured and described by Miller and Gurley as one of their types of *Cyclocystoides illinoisensis* (Fig. 28 on Plate 5, Bull. Illinois State Mus. Nat. Hist., 1895; also Plate I, Fig. 18 of the present paper). This specimen was described as having 13 submarginal plates, forming not much, if any, more than one-half of a circle. From this the inference is drawn that the complete specimen had 24 to 30 plates. As a matter of fact fourteen plates and half of a fifteenth are present, there are sufficiently distinct impressions to indicate the former presence of three additional plates, and their total number could not have exceeded 20, although apparently there is room only for 18 or 19. The radial cross-section of the plates is subtriangular, with the inner face abruptly vertical as in *Cyclocystoides ornatus*. The radially directed ribs on the upper faces of the latter are absent, but this upper surface is so badly worn in the Miller and Gurley specimen, here described, that the failure of these ribs to appear has no diagnostic value. There are four or five series of small plates in the marginal band surrounding the submarginal ring. In the opinion of the present writer, this specimen, the second one of those figured and described by Miller and Gurley, should be referred to *Cyclocystoides ornatus* Savage, and the name *Cyclocystoides illinoisensis* should be restricted to forms resembling Figure 27 accompanying their original description.

Miller and Gurley describe the plates of the marginal band as elongated nodes.

REMARKS.—The characteristic features of *Cyclocystoides ornatus* are the subtriangular radial cross section of the submarginal plates, with the inner face abruptly vertical, and the upper face crossed radially by 4 to 5 low ribs; the individual plates are much wider tangentially than long radially, and usually are distinctly separated from each other laterally, often from half to three-quarters of a millimeter.

14. *Cyclocystoides* (?) *illinoisensis* Miller and Gurley.

(Plate I, Figs. 17 A, B.)

Cyclocystoides illinoisensis Miller and Gurley, Bull. Illinois State Mus. Nat. Hist., 6, 1895, p. 61, Pl. 5, Fig. 27.

The species *Cyclocystoides illinoisensis* was founded on two fragments of the submarginal ring, found in the Orchard Creek shale, on Orchard Creek, near Thebes, in Alexander County, Illinois. These specimens differ in character. In the specimen described first, forming Figure 27 on Plate 5 accompanying the original description, (Plate I, Fig. 17A of present paper), 9 plates of the submarginal ring are present. These are nearly square in outline, neither the tangential nor the radial diameter differing far from 2 mm. The exposed surface is much flattened in a direction parallel to the disk, and the radial cross-section is very depressed elliptical, with a vertical diameter of 1 mm. The plates are in close contact laterally. Exterior to the submarginal ring are numerous small marginal plates arranged in short diagonal rows of 3 or 4 plates. Of these, those nearest the submarginal ring are nearly 1.5 mm. in width, while those nearest the free margin are much smaller.

In their description of this specimen, Miller and Gurley state that the nine large plates present appear not to form more than a third of a circle. In my own opinion, however, they form nearly half of the submarginal ring, the latter being somewhat elliptical in form. At least in a more complete specimen, (Plate I, Fig. 17 B) collected at the same locality, in the same shale, and preserved in the Museum of Illinois State University, exactly 20 plates are indicated either by plates actually present or by the impression left by those that are missing.

LOCALITY AND HORIZON.—From the Orchard Creek shale, on Orchard Creek, near Thebes, in Alexander County, Illinois. The type, numbered 6051A, is preserved in the Walker Museum, at Chicago University. The specimen here figured belongs to the Museum of the University of Illinois.

REMARKS.—The second specimen figured and described by Miller and Gurley under *Cyclocystoides illinoisensis* is regarded as belonging to *Cyclocystoides ornatus*, Savage, described from the same locality and horizon.

15. *Troostocrinus sanctipaulensis* Sp. nov.

(Plate I, Fig. 16.)

Closely similar to *Troostocrinus reinwardti* (Troost), from the Beech River division of the Brownsport limestone of Western Tennessee. Most of the differences are slight. The sinus in the upper part of the radials tends to be more narrow; the median part of the lower half of the radials, beneath the sinus, tends to be more angular, the intermediate part, along the sutures, being more or less concave; and the lower end of the radial sinus is slightly lower, being in direct contact with the most extended part of the median fold immediately beneath. Cross-sections of the theca agree in being pentagonal along the lower half of the radials and triangular along the basals, the angles occupying the median parts of each of the three basals. In the specimen figured, the basal part of the theca appears less attenuate but another specimen from the same locality shows greater attenuation. The most conspicuous differences are to be noted in the ambulacra. While the number of side-plates in the same length appears to be about the same, namely 16 in a length of 5 mm., the individual side plates appear to be more convex, the median line separating the side-plates is much more conspicuously grooved, and this groove zig-zags less from side to side.

LOCALITY AND HORIZON.—From the top of the Laurel limestone at St. Paul, Indiana. Four specimens numbered 22909, preserved in Walker Museum at Chicago University; only one is figured; another presents the details of the oral end of the theca.

REMARKS.—Whether the differences noted above are sufficient to warrant the erection of a new species is an open question. Additional specimens are necessary to determine how constant the differences noted are. Students of the crinoidea are aware of the frequency with which species occurring at St. Paul find their nearest relatives in the Waldron, Brownsport, and Racine, many of them showing Gotlandian affinities. From this point of view, the occurrence of the blastoid *Troostocrinus*, hitherto known only from higher strata, in the upper part of the Laurel formation at St. Paul is entirely normal.

16. *Troostocrinus reinwardti-minimus* Var. nov.

(Plate I, Fig. 14.)

Closely related to *Troostocrinus reinwardti*, from the middle or *Troostocrinus* zone of the Beech river division of the Brownsport formation in western Tennessee. It differs in being much smaller, and more slender; compared with the total length of the radials, the triangular parts between the radial sinuses are relatively shorter; moreover, the

tips of these triangular parts tend to be less convergent. Along the sutures between the radials the theca is sufficiently concave to give a distinctly pentagonal cross-section to the upper half of the theca, while the basal part has a triangular cross-section, as is usual in this genus.

LOCALITY AND HORIZON.—From the Bainbridge phase of the Niagaran, six miles west of St. Marys, in St. Genevieve County, Missouri. Collected by Doctor Herrick E. Wilson, and numbered 14791 in the collections of Walker Museum at Chicago University.

REMARKS.—The following new species have been described from the Niagaran locality at St. Marys, all by Prof. R. R. Rowley: *Cordylocrinus* ? *dubius*, *Cyathocrinus ovalis*, *Lecanocrinus hemisphericus*, *Pisocrinus glabellus*, *Pisocrinus granulatus*, *Scenidium* ? *nodocostatum*, and *Stribalocystites missouriensis*. In addition to these, Prof. Rowley identified two species as *Pisocrinus globosus* Ringueberg and *Pisocrinus gorbyi* Miller. The fauna is regarded as equivalent to some part of the Brownsport formation of western Tennessee.

Troostocrinus ? *dubius* and *Melocrinus wittenbergensis* were described by Rowley from a Helderbergian locality near Wittenberg, Missouri. The *Troostocrinus* should be re-examined to verify its generic reference.

Of the species listed, *Scenidium nodocostatum* belongs to the same group as the species described originally by Hall and Whitfield, from the Louisville limestone of Kentucky, as *Orthis nisis*. This is not a *Scenidium*.

17. *Troostocrinus subcylindricus* (Hall and Whitfield).

(Plate III, Figs. 3 A, B, C.)

Pentremites subcylindrica Hall and Whitfield, Geol. Surv. Ohio, Pal. 2, 1875, p. 129, Pl. 6, Fig. 13.

As in all other *Eublastoidea*, 5 fork-shaped radials are supported by 3 basals. The bases of the right posterior and left anterior radials rest on the truncated tops of two of the basals, the top of the third basal, occupying the right anterior interradius, being acutely angular. Theoretically, each of the two truncated basals was formed by the lateral coalescence of two basals. Only the posterior deltoid can be detected readily, the other four being restricted to the extreme tip of the acute interradian areas. The anal aperture opens through the oral extremity of the posterior deltoid.

In *Troostocrinus subcylindricus*, the surface of the radials rises on approaching the radial sinuses, the rise increasing toward the lower end of the sinuses. Immediately beneath the lower end of the sinuses the

median part of each radial curves conspicuous outward for a distance of about one millimeter. Near mid-height of the radials the cross-section of the theca is pentagonal but along the basals this cross-section changes to triangular, as in other species of *Troostocrinus*.

In the type (Plate III, Fig. 3A), the distance between the base of the radials and the lower end of the ambulacra is 17 mm., and from the latter to the acute tip of the areas between the sinuses the distance is about 11 mm. The lateral diameter of the theca just beneath the projecting lower ends of the sinuses is 15 mm. The basals diverge rather strongly, as in figure 3B on Plate III. The divergence of the lower part of the radials is much less, giving rise to the specific name *subcylindrica*. In another specimen (Plate III, Fig. 3C), recently found at Cedarville, Ohio, the theca is much more elongate.

LOCALITY AND HORIZON.—From the Cedarville dolomite. The type, numbered 3306, accompanied by the basal part of another specimen, is in the Museum of Ohio State University; both specimens were obtained at Yellow Springs, Ohio. A third specimen, here figured, was obtained in the quarry at Cedarville, Ohio.

REMARKS.—*Troostocrinus subcylindricus* is characterized by the strong outward curvature of the median part of the radials immediately beneath the lower end of the radial sinuses. This is shown conspicuously on lateral view.

In *Troostocrinus reinwardti*, from the Brownsport formation of Western Tennessee, there is no corresponding outward curvature of the median part of the radials. On the contrary, on lateral view the median parts of the radials curve slightly inward rather than conspicuously outward just before reaching the lower end of the radial sinuses. The length of this convex curvature is only about one millimeter. Moreover, the lower third of the theca usually is much more slender, the lower half of the radials diverging more strongly. In the Brownsport species, the side-plates number about 16 in a length of 5 mm. The surface of the ambulacra, compared with that of other species, is distinctly flattened, the groove between the series of side-plates being not consicuous, nor straight, but zigzagging rather strongly between the alternating side-plates.

18. *Troostocrinus* sp.

(Plate I, Fig. 15.)

Only a single specimen of *Troostocrinus* is known from the Chicago area. This specimen is numbered 22907 in Walker Museum at Chicago University, and is from Bridgeport, Illinois. It evidently is from the

Racine horizon. Considering the close resemblance between the Racine faunas of Illinois and Wisconsin and the Cedarville fauna of Ohio, this Bridgeport specimen might be expected to show close affinity to *Troostocrinus subcylindricus* (Hall and Whitfield), from the Cedarville dolomite. Compared with the latter it presents the following differences:

The radial sinuses are more narrow, varying from 1 mm. to slightly over 1.5 mm. in width. The triangular areas between these sinuses are relatively shorter, have a somewhat wider apical angle, are only slightly concave, and are more strongly and more abruptly inflected toward one another. Near the lower end of the radial sinuses the cross-section of the theca is pentagonal, the lower half of the radials being angular along the median line, but their curvature along this line is not outward on approaching the lower end of the sinuses, as in *Troostocrinus subcylindricus*. All parts of the theca are relatively shorter than in the latter species, the result being a blunter top, and a more rapidly attenuating base to the theca.

Compared with *Troostocrinus sanctipaulensis*, the theca is similar to the figured specimen, in the shorter form and resultant outline, in the narrowness of the radial sinuses, and in the absence of any outward curvature of the median part of the radials just beneath the lower end of the radial sinuses. It differs in the triangular areas between these sinuses being shorter and less abruptly curved inward.

Additional specimens will be needed to discriminate this form if it be distinct from those already described.

19. *Crinocystites chrysalis* Hall.

(Plate I, Figs. 2 A, B; 3 A, B.)

Crinocystites chrysalis Hall, 20th Rep. New York State Cab. Nat. Hist., 1868, p. 318, Pl. 12a, Figs. 10, 11.

The type of *Crinocystites chrysalis* (Plate I, Figs. 2 A, B), from the Racine dolomite at Racine, Wisconsin, is preserved in the American Museum of Natural History, in New York City. As figured by Hall, this type consists of a clavate, moderately curved body; the sutures between the plates are represented correctly, but there are no arm supports, the specimen having been incorrectly interpreted in this respect. Both of the figures presented by Hall are inverted from their natural position.

Arthur W. Slocum, the curator of the Walker Museum at Chicago University, called my attention to the fact that *Crinocystites chrysalis* was merely the cast of the interior of some other body whose exterior aspect was very different. This was shown by specimen 22914 in Walker Museum, which came from the same horizon and locality as the type of *Crinocystites chrysalis*. Prof. Stuart Weller at once recognized the similarity of this specimen to *Eucalyptocrinus proboscidioides* Miller (Plate I, Fig. 4) from the Cedarville dolomite, at Pontiac, Ohio (Jour. Cincinnati Soc. Nat. Hist., 5, 1882, p. 224, Pl. 9, Fig. 2). Formerly Pontiac was the seat of a lime industry. It was a railroad station, five miles south of Sidney, in Shelby County. Here the Racine phase of the Cedarville dolomite is exposed.

A comparative study of the type of *Crinocystites chrysalis*, of the Chicago University specimen of that species, and of *Eucalyptocrinus proboscoidalis* demonstrates that *Crinocystites chrysalis* is a cast of the interior of the anal tube of a species of *Eucalyptocrinus*, using that term in the broad sense in which it is applied at present. The following is a description of the Chicago University specimen.

Chicago University specimen.—The specimen retains distinct impressions of the exterior surface of the upper part of the 10 wing-like processes that surround the tegmen, and that serve as partitions between the vertical compartments sheltering the arms. No trace of these arms remains. The upper edge of these processes projects horizontally outward, their total extension across the entire width of the specimen being 18 mm., while 7 mm. farther down the attenuated upper part of the tegmen has a width of only 5 or 6 mm. The upper surface of the wing-like processes forms a platform, above which rises a further extension of the tegmen in the form of an anal tube. At its base this anal tube has a width of 7.5 mm., decreasing to about 3.5 mm. in a length of 14 mm., above which it is not preserved. The plates forming the anal tube are elevated towards their centers in a strongly nodose manner. They are arranged in about ten vertical series, the lower plate of each series being directly above the top of one of the wing-like processes already described. Four or five plates occur in each vertical series, as far as preserved, the plates in adjoining rows alternating with each other. Counted in a transverse direction, the plates at the base are arranged in circles of five plates each, the plates of successive circles alternating. It is not known whether the number of plates in a circle continues to be five as far as the top of the anal tube.

The cast of the interior of the anal tube is continued downward into the cast of the interior of that part of the tegmen which is included between the top of the wing-like processes. The upper part of this cast of the interior, for a length of 14 mm., retains traces of the plates forming the anal tube; the lower part, 6 mm. in length, shows a vertically elongated flattened area beneath each of the vertical rows of the anal tube, somewhat as in *Eucalyptocrinus proboscoidalis*. In the latter, however, that part of the tegmen which is included between the upper part of the wing-like processes is constricted strongly beneath while in *Crinocystites chrysalis* the corresponding part is constricted only sufficiently to give the entire cast included under that name by Hall an inverted clavate appearance, with the maximum expansion on a level with the top of the wing-like processes.

The Chicago University specimen agrees with the type of *Crinocystites chrysalis* in having the anal tube moderately curved lengthwise. That part of the cast of the exterior of the anal tube of the Chicago University specimen which is best preserved belongs to the concavely curved side of this tube, but the amount of this curvature is slight. That part of the cast of the interior of the anal tube which is best preserved belongs to convexly curved side of the tube. This curvature is more distinct, and this is the side of the tube here figured.

LOCALITY AND HORIZON.—From the Racine dolomite at Racine, Wisconsin. The Chicago University specimen is numbered 22914, and consists of the two parts described in the preceding lines. The type of the species, numbered 2023, is preserved in the American Museum of Natural History, and consists of the cast of the interior of the anal tube and of the top of the constricted part of the tegmen.

REMARKS.—While it is very probable that the Chicago University specimen here described belongs to the same species as the type of *Crinocystites chrysalis*, this is not absolutely certain. The anal tube of the latter is more curved lengthwise, is wider at the base, is more strongly clavate, and has a different arrangement of plates toward the top of the anal tube.

Eucalyptocrinus proboscidi Miller (Plate I, Fig. 4 of present paper), is a closely related species.

The form most closely resembling *Eucalyptocrinus proboscidi* is *Eucalyptocrinus egani* Miller (Jour. Cincinnati Soc. Nat. Hist., 3, 1880, Pl. 4, Figs. 1-1c), from the Racine dolomite at the Bridgeport locality, in Chicago, Illinois. From the figures accompanying the original description of this species it is evident that an anal tube extended above the platform formed by wing-like processes, but only the five lower plates of this tube are indicated on the cast of its interior, and it is not known definitely how much longer the anal tube was. The original specimen used for figure 1 c, accompanying the original description of this species, is in the museum of the Cincinnati Society of Natural History.

An anal tube rising above the platform of wing-like processes occurs also in a specimen from Racine, Wisconsin, which closely resembles *Eucalyptocrinus nodulosus* Weller, a cast of which is preserved in the Springer collection in the U. S. National Museum.

All of these species with anal tubes projecting above the platform of wing-like processes differ from *Eucalyptocrinus rosaceus* (Goldfuss), the type of the genus, from the Devonian of the Eifel, the anal opening of the latter consisting of a small aperture between four plates at the center of the platform.

Among European Calyptocrinids, the American species here discussed resemble most the form originally described by Phillips as *Hypanthocrinites decorus*. The latter also has an anal tube distinctly rising above the platform of wing-like processes.

In most American species of *Eucalyptocrinus*, the anal opening is among a series of small plates forming the central part of the flat platform of wing-like processes. Only in *Eucalyptocrinus lindahli* Wachsmuth and Springer do the wing-like processes extend strongly outward horizontally as in *Eucalyptocrinus rosaceus*, the genotype.

At present there is no disposition on the part of specialists to subdivide the genus *Eucalyptocrinus*, so that *Crinocystites chrysalis* may be regarded provisionally as the anal tube of some species of *Eucalyptocrinus*. Eventually, however, it may be found desirable to segregate those species in which the anal tube rises conspicuously above the platform of wing-like processes. In that case it may be necessary to determine whether the American species here discussed are as closely related to *Hypanthocrinites decorus* as the general appearance of the latter suggests.

***Eucalyptocrinus proboscidiialis* Miller.**

(Figure 4.)

Eucalyptocrinus proboscidiialis Miller, Jour. Cincinnati Soc. Nat. Hist., 5, 1882, p. 224, Pl. 9, Fig. 2.

Calyx obconical, rising from a small, flattened base, consisting of the basals alone. Radials almost as tall as wide; first costals fully as tall as wide; second costals with equilateral pentagonal outlines. First distichals about equal in size to the second costals, those of the same ray in contact with each other laterally, so that the interdistichal does not truncate the second costal but has an angular basal margin. Second distichals much smaller; the palmars which support the arms are not differentiated clearly; the interdistichal is narrower but slightly longer than the second distichals. The lower interbrachial is almost twice as tall as wide; it is surmounted by a pair of interbrachials the upper parts of which project distinctly above the general margin of the calyx. The width of the calyx at its upper margin is about four-fifths of its vertical height.

The lower part of the tegmen, for a vertical height of 5 mm., is only slightly narrower than the top of the calyx; above this point it contracts, at first rapidly and then more gradually, reaching its narrowest dimensions about 24 mm. above the top of the calyx. Farther up it widens again, at first gradually and then more rapidly, to a level 37 mm. above the top of the calyx, somewhat as in a very much elongated hour-glass. To this height extend the compartments sheltering the arms. Above this extends an anal tube about 53 mm. in length.

The lower part of the tegmen, for a vertical height of 11 mm., consists of a circlet of 10 oblong plates separated toward the base by a series of smaller plates, also 10 in number. Each of the 10 larger oblong

plates supports one of the vertical radiating wing-like partitions separating the compartments sheltering the arms. Alternating with the tops of the larger oblong plates is another series of plates, narrowing rapidly upward and forming the lower third of the tegmen. At its narrowest part, the diameter of this contracted portion of the tegmen is scarcely 3 mm.; the individual plates of this portion can not be differentiated in the type specimen. The upper third of the much elongated "hour-glass" portion of the tegmen consists of plates narrowing rapidly downward and producing a structure similar to an elongate funnel. The number of plates forming the circlet here can not be determined; it seems to be 8 but may be 10. The top of the funnel like portion of the tegmen widens into a narrow platform, apparently 18 mm. in width, forming the top of the compartments sheltering the arms. About halfway between the top of the calyx and the platform at the top of the funnel-like portion of the tegmen, the body of the crinoid enlarges to a diameter of 25 mm.

The anal tube rising above the platform of the tegmen is about 15 mm. wide at its base, and tapers gradually to a width of 4 mm. or less. It is composed of hexagonal plates which are almost equilateral at the base but become narrower and smaller farther upward.

At a distance of 15 mm. from the base of the calyx the column consists of columnals 3 mm. in height, intercalated between which are columnals only 1 mm. in height. Toward the base of the calyx, both sets of columnals diminish in height. The general diameter of the column is about 5 mm., but short vertical wing-like processes extend outward from the larger columnals and apparently also from the smaller columnals. In case of the larger columnals these wing-like processes slightly exceed 1 mm. in length. Apparently there are 5 of them within the circumference of each columnal.

The plates of the anal tube are very thick, those near the lower part of the tube varying from 2 to 3 mm. in thickness. The surface of these plates is coarsely and irregularly nodose, especially centrally. From this it is assumed that the plates of the calyx also probably were more or less protuberant centrally, and the

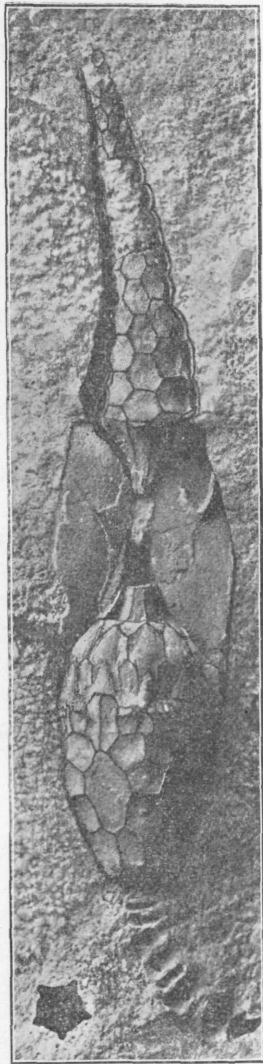


FIGURE 4.

Eucalyptocrinns proboscidi Miller. Type specimen. An outline of a columnal is added in the lower corner of the figure.

general surface may have been more or less coarsely papillate, but no direct evidence of this is at hand.

LOCALITY AND HORIZON.—From the Cedarville dolomite at Pontiac, six miles northeast of Piqua, Ohio. The type is numbered 13867 in the Museum of Ohio State University.

REMARKS.—In most species of *Eucalyptocrinus* the interdistichal truncates the top of the second costal. In *Eucalyptocrinus proboscidealisis* this is prevented by the lateral contact of those first distichals which belong to the same ray. Only two other American species of *Eucalyptocrinus* possessing this characteristic are known. One of these is *Eucalyptocrinus obconicus* Hall, described from the Racine dolomite at Racine, Wisconsin. In the type of this species the vertical height of the calyx is 19 mm., and its diameter at the top is almost seven-tenths of its height. The base of the calyx is obtusely rounded, instead of concave, and the basals may be seen on lateral view of the calyx, though only of short length.

The second of the American species mentioned above was described by Slocum, also under the name *Eucalyptocrinus obconicus* (Field Columbian Mus., 2, Geol. Series, 1908, p. 301, Pl. 86, Figs. 1, 2), though he suspected that it might be distinct. The type of this second species was found in the Racine limestone of the spoil heaps along the Chicago Drainage Canal near Lemont, Illinois. It differs from typical *Eucalyptocrinus obconicus* in being twice as tall and wide; the base of the calyx tapers to an acute angle; the basals are conspicuously taller and narrower; the radials, first costals, and interbrachials also are taller; the combined effect is to produce a more slender appearance along the lower half of the calyx. A cast of the exterior of this specimen shows that the exterior surface of the plates was convex but smooth. For this second species the term *Eucalyptocrinus slocumi* is proposed.

Extended anal tubes, similar to that of *Eucalyptocrinus proboscidealisis*, probably occurred also in *Eucalyptocrinus egani*, but the calyx of this species has an impressed base, and the interdistichal truncates the second costal. In species of *Calliocrinus* the concavity at the base usually is conspicuously deeper and wider than in typical *Eucalyptocrinus*.

20. *Periechocrinus cylindricus* Foerste.

(Plate III, Fig. 4.)

Periechocrinus cylindricus Foerste, Ohio Jour. Sci. 17, 1917, p. 244, Pl. 10, Figs. 1 A, B.

In the museum of Wittenberg College, at Springfield, Ohio, there is a calyx of *Periechocrinus cylindricus* nearly 80 mm. in length. Above the distichals the individual plates are not outlined clearly, but it is evident that in the case of each ray that part of the calyx which is directly above the first pair of distichals is somewhat tumid for a height and width of 13 or 14 mm., thus giving the top of the truncated calyx a somewhat pentagonal outline. Since only casts of the interior of the calyx are at hand, it is impossible to determine how large was the column at its attachment with the base of the calyx, but, as far as may be determined from the form of the base of the cast of the interior, the diameter of this column must have been small, almost too small to support a calyx of such large size.

EXPLANATION OF PLATES.

PLATE I.

FIG. 1. *Cælocystis subglobosus* (Hall).

A, anal side, with the two posterior rays, each branched. Small lateral branches of the main food-grooves alternate from side to side of the latter and lead to the facets supporting the brachioles. The margin of the anal orifice protrudes slightly. The attachment area for the column is 10 mm. in diameter. B, viewed from above, with the anal orifice at the top. Both views drawn from a wax cast of the hollow interior of a matrix preserving an impression of the exterior of a complete theca. Only the wax cast is known at present, but the cast shows plainly the presence of the cracks between the original rock fragments. No. 22906, in the Hindshaw collection, in the Walker Museum, at Chicago University. From the Racine dolomite at Chicago, Illinois.

FIG. 2. *Crinocystites chrysalis* Hall.

A, lateral view of cast of interior of an anal tube of some Calyptocrinid, regarded by Hall as the theca of some cystid. B, posterior view of the same. Both figures are reproductions of the figures accompanying the original description, in 20th Rep. New York State Cab. Nat. Hist., 1868, p. 318, Pl. 12a, Figs. 10, 11, but are published in a position inverted as compared with the original to indicate their position in the Calyptocrinid. From the Racine dolomite at Racine, Wisconsin. The type, numbered 2023, is preserved in the American Museum of Natural History.

FIG. 3. *Crinocystites chrysalis* Hall.

A, posterior view of cast of interior of an anal tube of some Calyptocrinid. When found this cast of the interior was still attached to the matrix of the specimen used for Figure B, which is an impression of the exterior of the same anal tube. Figure B was drawn from a clay cast of this natural impression. It shows the anterior or slightly concave side of part of the anal tube. The base of this figure shows the upper extensions of the wing-like expansions forming the compartments between which the arms of the Calyptocrinid are folded when at rest. Specimens numbered 22914, from the Hall collection in Walker Museum at Chicago University. From the Racine dolomite at Racine, Wisconsin.

FIG. 4. *Eucalyptocrinus proboscidiialis* Miller.

Cast of an almost entire specimen, chiefly of the interior, including the dorsal cup, the arching tegmen, constricted between the arms to a narrow tube expanding at the top of the partitions sheltering the arms, surmounted by a long anal tube. Republished from Jour. Cincinnati Soc. Nat. Hist., 5, 1882, p. 224, Pl. 9, Fig. 2, for comparison with that specimen of *Crinocystis chrysalis* which is used on the present plate for Figure 3B. Original figure prepared from a plaster cast of the original specimen, prepared by D. A. McCord, of Oxford, Ohio. Found in the Cedarville dolomite at Pontiac, south of Sidney, Ohio.

FIG. 5. *Gomphocystites indianensis* Miller.

A, Viewed almost directly from above, but with part of the base showing. Anal aperture a short distance above and toward the left of the mouth. B, Lateral view, with the anal aperture directly beneath the mouth. The exact shape of the base of the specimen is unknown. From the Osgood formation, in Jefferson County, Indiana. Type numbered 6019, in Walker Museum at Chicago University.

FIG. 6. *Gomphocystites bownockeri* Sp. nov.

A, Upper surface of theca, with anal aperture a short distance on the left of the oral aperture. B, Lower part of another specimen showing the ends of two of the rays, drawn so as to indicate the probable form of the complete specimen. There is a possibility that originally these two specimens belonged together, but the broken parts no longer match. Specimens numbered 22943, collected by H. H. Hindshaw, and now in the Walker Museum at Chicago University. From the Racine dolomite at Chicago, Illinois.

FIG. 7. *Hallucystis imago* (Hall).

Lateral view showing the pectinirhomb of Plates 12 and 18, the anal aperture being on the right. This probably is the form for which Jaekel proposed the term *Hallucystis elongatus*. Specimen numbered 22908 in the Walker Museum of Chicago University. From the Racine dolomite at Chicago, Illinois.

FIG. 8. *Hallucystis imago* (Hall).

A small theca with 5 series of plates, the plates of the middle series not being in contact with each other. Numbered 21734, from the Van Horne collection, in Walker Museum at Chicago University. From the Racine dolomite at Racine, Wisconsin.

FIG. 9. *Gomphocystites bownockeri* Sp. nov.

A, Viewed from above, with the anal aperture directly above the oral opening. B, Lateral view, with a glimpse of the anterior ray at the extreme upper left-hand margin of the figure, the tip of the right anterior ray showing at the lower right-hand margin. Numbered 22945, collected by H. H. Hindshaw, and preserved in Walker Museum at Chicago University. Found in the Racine dolomite in the Bridgeport quarry at Chicago, Illinois.

FIG. 10. *Lysocystites* (?) *nodosus* (Hall).

Exterior of theca. Figure prepared from a clay cast of an impression of the exterior of a specimen in a rock fragment. This impression shows chiefly the characteristics of the exterior but some of the structural features near the surface also have left their traces, especially at the nodes and along the coarser radiating ribs. Specimen numbered 2193, from the James collection in Walker Museum at Chicago University. From the Cedarville dolomite at Wilmington, Ohio.

FIG. 11. *Lysocystites nodosus* (Hall).

A, Cast of interior of theca viewed from above, with anus. The tips of the inverted cuneate elevations of the cast are seen at the lower angles of the five plates belonging to the third series of thecal plates. A single plate intercalated in the third series is in contact with the lower margin of the anal aperture. No fourth series can be recognized. B, lateral view of the same, the cast showing an oblong elevation at the upper end of one of the sutures between the basal plates;

also the characteristic cuneate elevations at the top and bottom of the second series of plates. C, Basal view of the same, showing both the cuneate and the oblong elevations. At the center is a small triradiate structure, of which the median ray points toward the right anterior interradius. The stem appears to have been of remarkably small size. Specimen numbered 21815, from the Van Horne collection in Walker Museum at Chicago University. D, Cast of interior of another specimen, with anal aperture at lower margin of figure, left of the median line. Specimen numbered 18943, from the Gurley collection at Chicago University. From the Racine dolomite at Racine, Wisconsin.

FIG. 12. *Wellerocystis kimmswickensis* Gen. et Sp. nov.

A, Viewed from above, with anus. B, Lateral view, with anus on upper right-hand side, showing that the arm plates occur in single series; along the arm curving around the anal aperture these arm-plates are seen to line only one side of the main food-groove. The arm on the left side of the anal aperture is curved but appears straight from the point of view seen in the figure. A third arm lines the upper left-hand margin of the figure. Specimen numbered 10727, collected by Prof. Stuart Weller, and preserved in Walker Museum of Chicago University. From the Kimmswick limestone near Glen Park, Missouri.

FIG. 13. *Allocystites hammelli* Miller.

A, Viewed from above, with aperture at the top of the figure apparently pentagonal in form and elevated above the general surface of the theca. The transverse ridge near the middle of the figure is interpreted as locating the madreporite. The anal aperture is slightly below the middle of the figure and is more or less quadrangular in outline. B. Specimen numbered 6006, in Walker Museum of Chicago University. From the Osgood formation on Rikers Ridge, northeast of Madison, Indiana.

FIG. 14. *Troostocrinus reinwardti* minimus Var. nov.

Lateral view, with left anterior radial in front. Specimen numbered 14791, collected by Dr. H. E. Wilson, and preserved in Walker Museum of Chicago University. Found 6 miles west of St. Marys, Missouri.

FIG. 15. *Troostocrinus* sp.

Lateral view, with right posterior radial in front. Specimen numbered 22907, from the Van Horne collection, in Walker Museum at Chicago University. From the Racine dolomite at the Bridgeport quarry, at Chicago, Illinois.

FIG. 16. *Troostocrinus sanctipaulensis* Sp. nov.

Lateral view, with right posterior radial in front. Specimen numbered 22909, from the Washburn collection, in Walker Museum at Chicago University. From the top of the Laurel limestone at St. Paul, Indiana.

FIG. 17. *Cyclocystoides* (?) *illinoisensis* Miller and Gurley.

A, Part of the main ring consisting of large plates, with a trace of the surrounding peripheral margin, consisting of small imbricating plates. Type of the species, numbered 6051 A in the collections of Walker Museum at Chicago University; the original of figure 27 on Plate 5 of Bull. 6, Illinois State Mus. Nat. Hist., 1895. Found in the Orchard Creek shale, south of Thebes, Illinois. B, A more complete specimen from the Savage collection at the University of Illinois, found at the same locality and horizon.

FIG. 18. *Savagella ornatus* Savage.

Specimen badly weathered, some of the lower plates of the ring of large plates considerably displaced, but their position indicated by depressions in the rock. Part of the peripheral margin of small imbricating plates preserved. Original of Fig. 28 on Pl. 5, of Bull. 6, Illinois State Mus. Nat. Hist., 1895. From the Orchard Creek shale, south of Thebes, Illinois.

PLATE II.

FIG. 1. *Cælocystis subglobosus* (Hall).

A, Type, viewed from above. Specimen distorted, with pectinirhomb on plates 14 and 15; apical end crowded toward lower right-hand corner. B, lateral view, showing pectinirhomb on plates 1-5, and 14-15. Specimen numbered 2027 and preserved in the American Museum of Natural History in New York City. From the Racine dolomite at Racine, Wisconsin.

FIG. 2. *Cælocystis subglobosus* (Hall).

A, Lateral view showing pectinirhomb on Plates 12-18, and along the lower left-hand margin a faint indication of the pectinirhomb on plates 1-5. B, Lateral view, showing anal aperture and pectinirhomb on Plates 12-18. From the Welch collection deposited in Wilmington College, at Wilmington, Ohio. Found in the Cedarville dolomite in the Moodie quarry in that city.

FIG. 3. *Cælocystis subglobosus* -(Hall).

A, Viewed from above, showing anal aperture and pectinirhombs on plates 14-15 and 12-18, also the divided madreporite plate 23, not numbered in the figure. B, Lateral view, showing the anal aperture and marginal views of the same pectinirhombs. C, Basal view, showing the pectinirhomb on plates 1-5; also the tendency toward a quadrangular outline of the impression produced by the invagination of the basal plates on the cast of the interior. The size of the attachment area for the column is indicated. From the Cedarville dolomite at Cedarville, Ohio.

FIG. 4. *Cælocystis subglobosus* (Hall).

Oblique lateral view of distorted specimen, showing anal aperture and marginal view of pectinirhomb 12-18. Specimen numbered 1603 in the Illinois State Museum at Springfield, Illinois. From the Racine dolomite at Racine, Wisconsin.

FIG. 5. *Cælocystis subglobosus* (Hall).

A, Theca viewed from above, showing protruding anal aperture, the pectinirhomb on Plates 14-15, a marginal glimpse of that on plates 12-18, and relatively numerous instances of divided or supplementary plates. B, Same, viewed from in front. D, Same, viewed from the side. C, Basal view of another specimen showing pectinirhomb on plates 1-5; also the quadrangular invaginated base of the cast of the interior. Specimens numbered 35155 and 35061 respectively in the U. S. National Museum at Washington, D. C., the originals of plate diagrams 37 and 36 of Schuchert in his paper on Siluric and Devonian Cystidea and Camarocrinus, Smithsonian Miscellaneous Collections, Vol. 47, Pt. 2, 1904, pp. 248 and 247. From the Racine dolomite at Chicago, Illinois.

FIG. 6. *Callocystites jewetti-elongata* Foerste.

Base of another specimen, showing pectinirhomb on plates 1-5; also large size of attachment area for column. From the Cedarville dolomite at Cedarville, Ohio.

FIG. 7. *Hallucystis imago* (Hall).

A, Lateral view with anal aperture along the margin on the right of the figure, also the pectinirhomb on plates 12-18, and a marginal view of that on plates 1-5 along the lower left-hand margin. B, Lateral view, showing pectinirhomb on plates 1-5. C, Basal view, showing the same pectinirhomb, also the small area for the attachment of the column. From the Cedarville dolomite at Cedarville, Ohio.

FIG. 8. *Cælocystis subglobosus* (Hall).

Figure prepared from a clay cast of an impression showing part of the width of an entire theca and the attached column. The entire theca was about 4 mm. wider. Even with this increased width the column is relatively very large. Pectinirhomb on plates 1-5, and impressions of the recumbent rays, showing branching. Surface pitted. From the Cedarville dolomite at Springfield, Ohio.

FIG. 9. *Gomphocystites bownockeri* Sp. nov.

A, Lateral view, showing anal aperture, with the left posterior ray along the upper margin of the figure, the right posterior and right anterior rays occurring at successively lower parts of the theca. B, Viewed from above, with anal aperture slightly above and toward the left of the oral aperture. From the Cedarville dolomite at Cedarville, Ohio.

PLATE III.

FIG. 1. *Gomphocystites bownockeri* Sp. nov.

A, Lateral view of an imperfect specimen showing two of the five food-grooves encircling the upper part of the theca in a dextral direction; the lower of these in the figure is the left anterior food-groove, and the upper one is the anterior food-groove. On the right half of the theca, near midheight of the more globose part, is an approximately horizontal series of small plates connecting on the right with the tip of the left posterior food-groove. B, Oblique view of the same specimen showing the two food-grooves mentioned before, above which, in succession, are the right anterior food-groove, and the right posterior one, the latter curving toward the right, close to the left margin of the anal opening, as seen from the point of view of the figure. The pentagonal depression containing the oral aperture is best seen in Figure B. From the Cedarville dolomite at Cedarville, Ohio. No. 8736 in the Museum of Ohio State University.

FIG. 2. *Gomphocystites* sp.

A, Lateral view, showing in succession, from below upward, the left posterior, left anterior, and anterior food-grooves, with a faint view of the right anterior food-groove at the extreme top of the figure. B, View from above, showing four of the food-grooves, the right posterior one curving downward on the right side of the anal aperture, in the figure; then follow in succession the right anterior, anterior and left anterior food-grooves, with the proximal part of the left posterior one indicated on the left side of the right posterior food-groove. The proximal parts of the two posterior food-grooves are not distinctly preserved in the specimen figured and are added here to assist in orienting the specimen. From the base of the Louisville limestone, two miles east of Anchorage, Kentucky.

FIG. 3. *Troostocrinus subcylindricus* (Hall and Whitfield).

A, Type, with the right posterior radial on the left side of the figure. B, Lower half of a theca, with the left anterior radial in the center of the figure. C, Theca with the right posterior radial in the center of the figure. In B and C the truncated basals are angulated along their median lines. From the Cedarville dolomite. A, B, from Yellow Springs, Ohio, are numbered 3306 in the Museum of Ohio State University. C, from Cedarville, Ohio.

FIG. 4. *Periechocrinus cylindricus* Foerste.

Calyx, slightly swollen just beneath the right anterior (RA), right posterior (RP), and left posterior (LP) groups of arms. From the Cedarville dolomite, at Springfield, Ohio. In the Museum of Wittenberg College, at Springfield, Ohio.

FIG. 5. *Celocystis subglobosus* (Hall).

Plate diagram of specimen numbered 1603, in the Illinois State Museum of Natural History, in Springfield, Illinois; from the Racine dolomite at Racine, Wisconsin.

FIG. 6. *Celocystis subglobosus* (Hall).

Plate diagram of type, numbered 2027 in the American Museum of Natural History in New York City; from the Racine dolomite at Racine, Wisconsin. The dotted lines indicate the parts not distinctly defined in this type.

PLATE IV.

FIG. 1. *Holocystites alternatus* Hall.

Specimen numbered 839 in the Milwaukee public museum, of Milwaukee, Wisconsin. From the Racine limestone at Racine, Wisconsin.

FIGS. 2, 3, 4. *Holocystites alternatus* Hall.

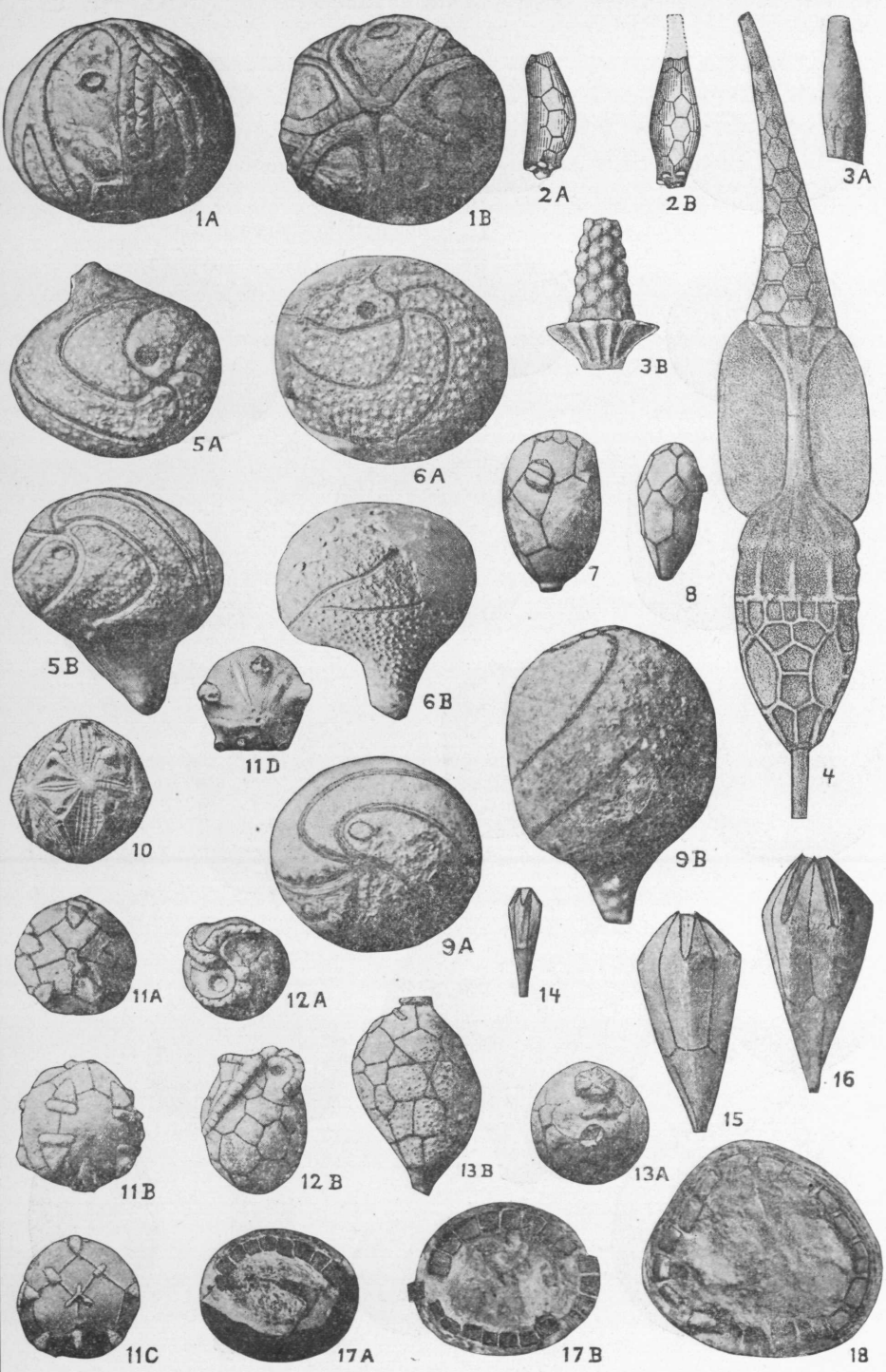
Three specimens from the Cedarville dolomite at Cedarville, Ohio.

FIG. 5. *Holocystites alternatus* Hall.

From the Moodie quarry, in the southeastern part of Wilmington, Ohio; in the Cedarville dolomite. In the Welch collection.

FIG. 6. *Holocystites alternatus* Hall.

Type, numbered 2020, in the American Museum of Natural History in New York City. From the Racine dolomite at Racine, Wisconsin. Figure copied from 20th Rep. New York State Cab. Nat. Hist., 1868, Pl. 12a, Fig. 6.

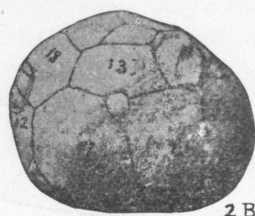




1A



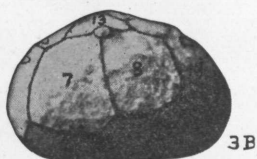
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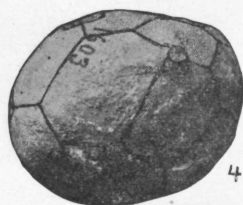
2B



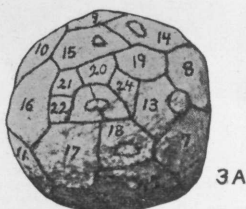
1B



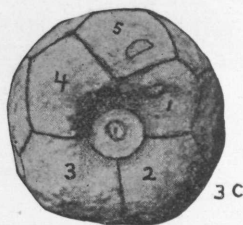
3B



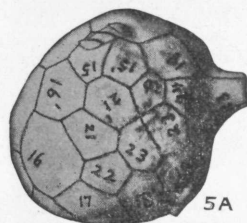
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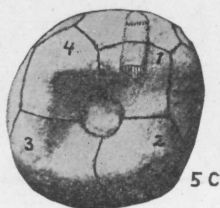
3A



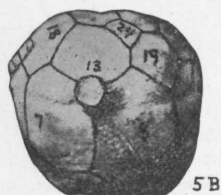
3C



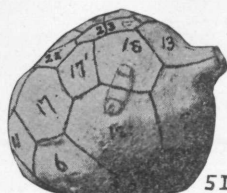
5A



5C



5B



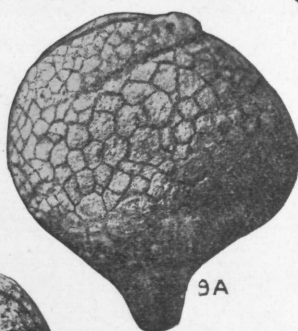
5D



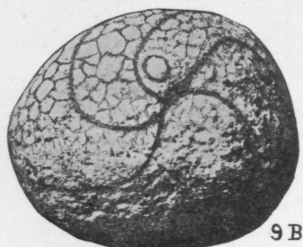
7A



6



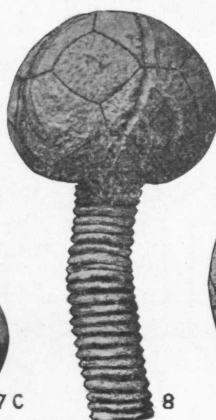
9A



9B



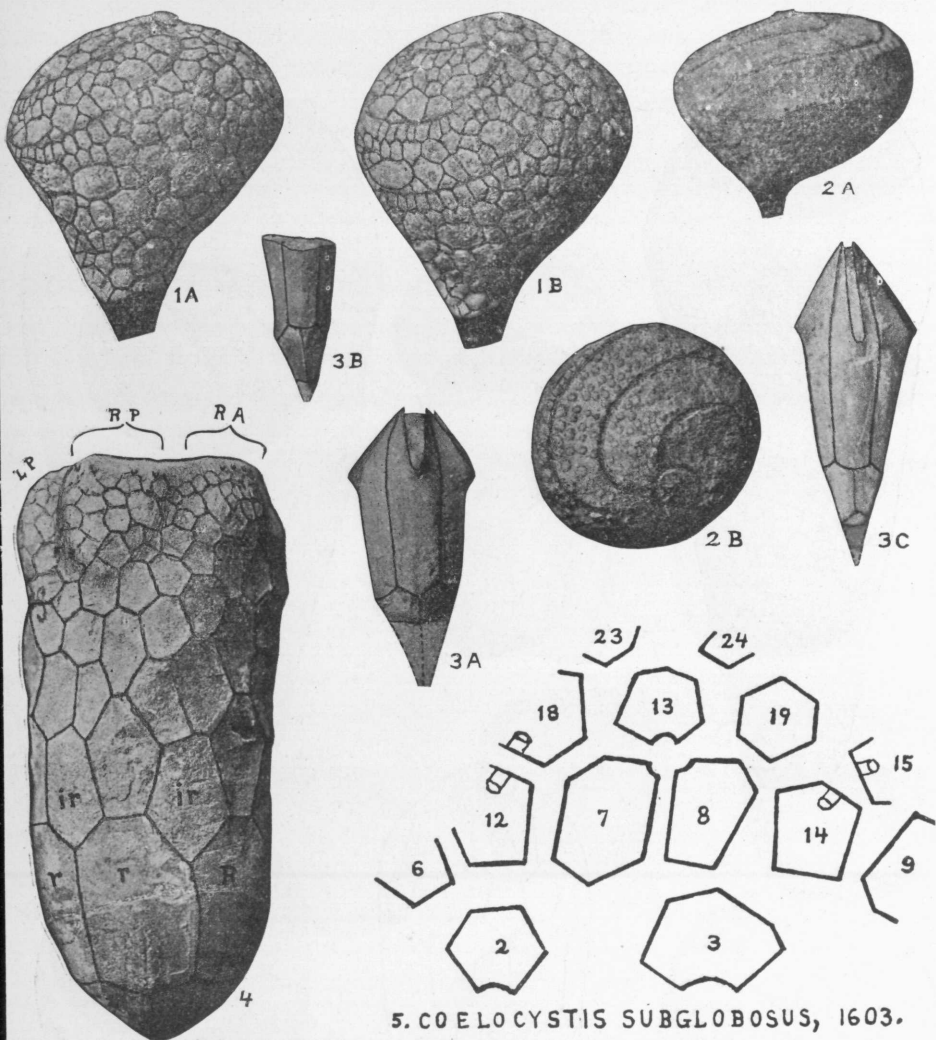
7C



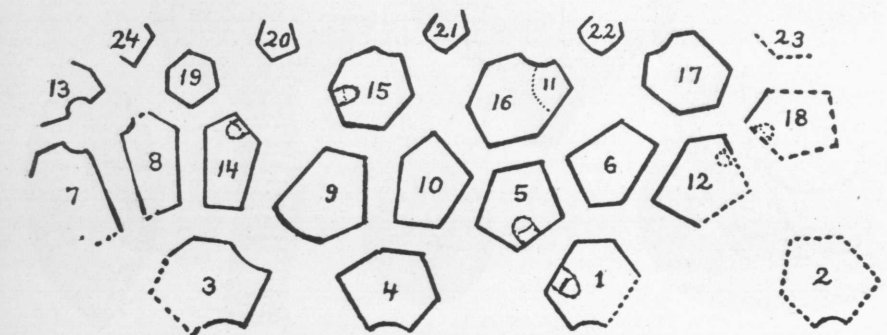
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7B



5. COELOCYSTIS SUBGLOBOSUS, 1603.



6. PLATE DIAGRAM OF COELOCYSTIS SUBGLOBOSUS, TYPE, 2027.

